Retaining Wall 6.50L Geotechnical Design Memorandum

WSDOT I-405 Renton to Bellevue Widening and Express Toll Lanes
Renton to Bellevue, Washington

November [illegible], 2021

WSDOT Contract No. 9242
Terracon Project No. 81215044

No. 1 Date 11/30/21

CHECK PRINT

Drawings checked against calculations and calculation check confirmed

by NA Date

Checked P. Palmerson Date 11/30/21

Backchecked R. Sargent Date 01/07/22

Corrected ________ Date ________

Verified ________ Date ________

Prepared for:
Parsons

Prepared by:
Terracon Consultants, Inc.
Mountlake Terrace, Washington

terracon.com

Terracon

Environmental • Facilities • Geotechnical • Materials

Revision History

Date	Revision
10/29/21	IR-CR
11/29/21	Final

November 30, 2021

Parsons Transportation Group
600 University Street, Suite 700
Seattle, WA 98101

Attn: Mr. Paul Dickman~~.~~
P: (602) 284-3609
E: paul.dickman@parsons.com

RE: Retaining Wall 6.50L
I-405 Renton to Bellevue Widening and Express Toll Lanes Project
I-405 MP 0.0 to 14.6
King County, WA
WSDOT Contract No. 9242
Terracon Project No. 81215044

Dear Mr. Dickman:

Terracon Consultants, Inc. (Terracon) is pleased to present this Geotechnical Design Memorandum for Wall 6.50L as part of the above referenced project. This report presents our analyses and recommendations for design and construction of the soil nail and special barrier walls.

The information evaluated for this report includes data presented in the Request for Proposal (RFP) Documents, prior exploration and geotechnical work completed by Wood Environment and Infrastructure Solutions, Inc (Wood). This report was prepared in accordance with the requirements of RFP Section 2.6.5.3 of the project Technical Requirements. Geotechnical design was performed in accordance with the project Mandatory Standards identified in Section 2.6.2 of the project Technical Requirements current version at the time of award.

We appreciate the opportunity to be of service to Parsons and the Flatiron-Lane Joint Venture. Please let us know if you have any questions regarding this design information.

Sincerely,
Terracon Consultants, Inc.

Yashar Yasrobi, P.E.
Project Engineer

Pete Palmerson, P.E.
Geotechnical Department Manager

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WSDOT Contract No. 9242
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1.0 DESCRIPTION

This Geotechnical Design Memorandum provides recommendations regarding the design and construction of Retaining Wall 6.50L. This report is based on our present knowledge of the proposed construction, the retaining wall plans as provided in Appendix A, coordination with other design disciplines and contractor's representatives on the project team.

2.0 PLANNED CONSTRUCTION

The retaining wall plan and profile that form the basis of our design are shown in Appendix A Retaining Wall Plans. As currently proposed, Wall 6.50L is a combination special design barrier and soil nail wall. The wall is located along on the west side of southbound I-405 to accommodate road widening at the NE 30th Street Overcrossing. Description of the wall characteristics are provided below in Table 1.

TABLE 1 - WALL TYPE/DESCRIPTION

Retaining Wall ID	6.50L
Type	Special Barrier/Soil Nail Wall
Begin Soil Nail Wall	SB405 STA 5646+03.79 (33.33' LT)- Wall STA 0[illegible].00
End Soil Nail Wall	SB405 STA 5647+69.58 (33.80' LT)-Wall STA [illegible]0.00
Soil Nail Wall Height (ft)	3.6 to 7.3
Soil Nail Wall Length (ft)	165
Special Design Barrier	North and South ends of soil nail wall, limits shown on roadway plans
Special Design Barrier Max Height (ft)	Up 3.5
Existing Borings	H-2-79, H-2-81, W-80[illegible]

3.0 PROJECT GEOLOGY AND SOIL CONDITIONS

Upon review of the boring logs, the subsurface stragitgraphy was broken out into Engineering Stratigraphic (or Soil) Units (ESUs). ESUs are grouped together based on geologic origin, engineering soil properties and anticipated behavior with respect to the proposed improvments. For project consistency, we have continued the geologic unit descriptions and their identification as specific ESU as previously characterized by Wood, Hart Crowser and GeoEngineers. The

ESUs encountered at the subject site, along with a brief discussion of their descriptior sed for the project geology are provided in Table 4. Engineering properties of the ESUs enc tered are discussed in Section 5.

3.1 Site Soil Conditions

Subsurface exploration data was provided in the Washington Stat Department of Transportation's (WSDOT's) Geotechnical Data Report (GDR). An additic exploration was advanced by Wood. The boring locations are shown on the plan view in Ap dix A. A subsurface profile are presented Section 2 of the attached calculations. Copies of the ing logs are provided in Appendix B: Historic Borings. Table 2 summarizes the borings we nsidered for design of retaining wall 6.50L.

TABLE 2 –BORING SUMMARY

Boring Number	Date Completed	Boring Depth (ft.)	G nd Surf Elevation MSL)[1]	Groundwater Elevation (ft. MSL)
W-80-20	6/4/2020	20.6	219.6	Dry
H-2-79	12/18/1979	47.9	224	192
H-2-81	3/7/1981	20	211.3	205.3

Notes:
1. Ground surface elevations are rounded to the est 0.1 feet

3.2 Groundwater Conditions

Groundwater was noted in two of the borin elow the proposed improvements. The occurrence and elevation of groundwater is expect o be variable and to fluctuate seasonally due to variations in the amount of precipitatio vaporation, and surface water run-off. Our analyses used a groundwater elevation of 209 f .

4.0 GEOLOGIC HAZAR

4.1 Seismic Site Class a Design Parameters

Seismic design parameters f Vall 6.50L are based on the general procedure, as outlined in AASHTO LRFD Bridge Des Specifications (AASHTO) Section 3.10.2.1, are provided in Table 3 below. The parameters based on a design seismic event with a seven percent probability of being exceeded in 75 s using the USGS National Hazard Maps (2014). The site coefficients have been modified in cordance with Section 4.2.3.1 of the BDM.

The weighted aver Standard Penetration Test (SPT) blow count (blows per foot) for the borings, extrapol to a depth of 100 feet of the soil profiles was used to determine the site

Commented [SRW1]: Why elevation 209 feet? This is about 4 feet higher than observed.

Commented [PPJ2R1]: conservative

class in accordance with the LRFD Bridge Design Specifications (AASHTO 2017). The results of the analyses indicate the site should be classified as Site Class D.

TABLE 3 - SEISMIC DESIGN PARAMETERS

Parameter	Value
Site Class	[illegible]
Peak Ground Acceleration (PGA)	[illegible]
FPGA	[illegible]175
Site-Adjusted Peak Ground Acceleration (AS)	0.50
Mean Magnitude Earthquake (Mw)	7

The peak horizontal ground acceleration (PGA) for the Site Class B/C boundary recommended in Table 3 does not include amplification or damping due to the site soils. In order to assess seismic earth pressures and inertial effects on the wall, the PGA for Class B rock needs to be adjusted for the site soil conditions. We have used the site coefficients in the [illegible] to calculate an effective peak ground acceleration coefficient (As) of 0.50 to be used for liquefaction analyses. For seismic design of the walls as wells as the pseudostatic analy

4.2 Liquefaction

Liquefaction is a phenomenon in which saturated cohesionless soils are subject to a temporary but essentially total loss of shear strength under the reversing cyclic shear stresses associated with earthquake shaking.

Based on the depth to groundwater, the presence of cohesive soils and very dense glacial till at depth below the wall profile, we anticipate the liquefaction hazard to be low.

5.0 DESIGN SOIL PROPERTIES

5.1 Engineering Stratigraphic Units

Table 4 summarizes encountered geologic units and the assigned ESU used to develop recommendations for the retaining wall. As noted above, in the interest of maintaining consistency with previous work completed on the project we have adopted ESU units and descriptions used by Wood and adopted by Hart Crowser.

TABLE 4 – ESU DESCRIPTION

Geologic Units	Assigned ESU	ESU Description
Fill	1B	Fill- Silty Sand and Gravel, medium dense to dense
Recessional Outwash	3B	Medium dense to very dense Sand
Lacustrine Deposits	3E	Stiff to very stiff-Silt/Clay

TABLE 4 – ESU DESCRIPTION

Geologic Units	Assigned ESU	ESU Description
Glacial Till	4C	Dense to very dense Silty Sand and Gravel

A subsurface profile showing the relation ship of the wall to the ESU is shown in Appendix C.

5.2 ESU Design Soil Properties

Table 5 presents the ESU soil properties, which were used in calculations for the soil nail and special barrier walls. Detailed calculations and procedures for determination of soil properties are provided in the attached calculations package. It is important to note the the entire wall face and the bulk of the overburden consists of ESU 3B.

TABLE 5 – DESIGN SOIL PROPERTIES

ESU	Moist Unit Weight (PCF)	DRAINED CONDITION		UNDRAINED CONDITION	
		Friction Angle (degrees)	Cohesion (PSF)	Friction Angle (degrees)	Su[i] (PSF)
1B	125	35	50	35	200
3B	125	36	0	36	0
3E	120	32	50	0	1500
4C	135	40	200	40	200
Wall profile lies entirely within ESU 3B					

6.0 GEOTECHNICAL ANALYSIS AND DESIGN RECOMMENDATIONS

6.1 Standard Barrier Design Parameters

A special design barrier retaining up to 42 inches of soil is proposed beyond the soil nail limits for the north and south sections of wall. Table 6 below provides design parameters for the barrier based on the ESU 3B native soil which will be both the retained and foundation soil. Terracon has performed the global stability analyses and the structural engineer will perform the bearing, sliding and overturning analyses based on the values shown below

TABLE 6 – DESIGN PROPERTIES FOR SPECIAL BARRIER SECTION OF 6.50L

Retained/Bearing Soil (ESU 3B)	VALUE
Moist Unit Weight (PCF)	125
Friction Angle (DEG)	36
Active Earth Pressure Coefficient[1], Ka (DIM)	0.35
M-O Earth Pressure Coefficient[2], Kae (DIM)	0.79
Passive Earth Pressure Coefficient[3], Kp (DIM)2	6.0
Sliding Coefficient[4] (DIM)	0.58
Minimum Embedment (FT)	1.0
Nominal Bearing Resistance[5] (KSF)	11
Service Limit State Bearing Resistance[6, 7, 8] (KSF)	13

Retained/Bearing Soil (ESU 3B)	VALUE

1) Active EP for 2:1 backslope using Coulomb's method where $\delta=2/3\phi$
2) Based on ½ As=0.25.
3) Passive EP for level toeslope using Coulomb's method where $\delta=1/3\phi$
4) Sliding coefficient based on Eqn 10.6.3.4-2 in the AASHTO LRFD Bridge Design Specifications (assuming precast barrier)
5) Nominal bearing resistance must be factored by a resisitance factor of 0.[illegible] for the Strength Limit State.
6) Resistance factor for the Service Limit State is 1.0.
7) Based on 1-inch of allowable settlement using Hough's method.
8) Based on 2.3 foot wide footing.

6.2 Soil Nail Wall Analyses

Critical wall cross sections were selected for analysis using engineering judgment by taking into consideration existing soil conditions, wall geometry and surcharge loading. These critical sections were analyzed for internal stability, compound stability, and global stability. Five design sections were analyzed.

The analyses were performed using SnailPlus (Deep Excavation, LLC. 2021) using an ultimate pullout value of 20 psi (4.5 KIPS/FT) assuming a 6-inch diameter nail hole.

The soil nail analysis was performed using allowable stress design (ASD) with the following factors of safety:

- Temporary: Pullout FS = 2, Bar yield FS = 1.8, Soil Shear Strength Minimum FS = 1.35
- Permanent Static: Pullout FS = 2.[illegible] Bar yield FS = 1.8, Soil Shear Strength Minimum FS = 1.5
- Permanent Seismic: Pullout FS = 1.5, Bar yield FS = 1.35, Soil Shear Strength Minimum FS = 1.1

The soil nail analysis was completed with the following surcharge loads:

- Traffic = 250 psf uniform (outside the bridge footing)
- 2:1 Backslope (outside the bridge footing)
- NE 30th Street Bridge Pier 1 Foundation: 4.36 KSF uniform soil pressure acting over a 9 foot by 65 foot spread footing with the closest footing edge a horizontal distance of approximately 5 feet behind the wall face for the static case.
- NE 30th Street Bridge Pier 1 Foundation: 7.93 KSF uniform soil pressure acting over a 9 foot by 65 foot spread footing with the closest footing edge a horizontal distance of approximately 5 feet behind the wall face for the seismic case.

6.3 Soil Nail Wall Recommendations

Based on the results of our analyses, we recommend the follow nail selection and pattern as outlined in Tables 7, 8 and 9. The top nail must be at least 2 feet below the ground surface behind the wall.

TABLE 7 – SOIL NAIL DESIGN STA 0+82 to 1+39

Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
12	5	~~21~~10.4	13.5~~21~~
1. Single row of nails in this section are #6, 75 KSI			

TABLE 8 – SOIL NAIL DESIGN STA 1+39 to 2+05

Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
20	4	~~45~~25	~~45~~26.2
1. Two rows of nails, rectangular pattern in this section are #10, 75 KSI 2. Use nonstructural filler under bridge footing (unbonded zone) 3. Double corrosion protection required			

TABLE 9 – SOIL NAIL DESIGN STA 2+05 to 2+50

Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
12	5	~~17~~10.2	~~17~~12.9
1. Single row of nails in this section are #6, 75 KSI			

Soil corrosivity in the nail zone is considered non-aggressive. Therefore, epoxy coated Grade 75 bar is specified for the entire wall. The WSDOT GDM requires that soil nail walls that are within the influence zone of spread footings be designed with double corrosion protection.

The soil nail length, reinforcement and nail spacing presented in the tables above are the layouts required to achieve the minimum factors of safety required for the design.

6.4 Global Stability

All wall sections were found to have an adequate factor of safety for global stability. Slide version 2 (Rocscience 2021) was used to model global stability with Spencer's and Bishop's method. In the static case (Service Limit State) surfaces were set to non-circular path search, with surface optimization selected. ~~No pseudostatic analysis was performed due to the wall height less than 4 feet.~~

Slide model output is presented in the following table. The GDM requires minimum factors of safety for global and compound stability of 1.3 in the static case, and 1.1 under seismic loading.

TABLE 10 - FACTORS OF SAFETY FOR GLOBAL STABILITY

Station	Static Factor of Safety	Pseudo-Static Factor of Safety
1+39.5	1.5	1.1
1+54	1.6	1.1
2+05	1.5	1.1
2+07	1.6	1.1
2+50	1.7	1.1

7.0 CONSTRUCTION CONSIDERATIONS

Pre-fabricated drainage mat should be placed against the soil face in vertical strips between every column of nails prior to placing each lift of shotcrete. Strips should be overlapped between each lift to provide a continuous drainage path. During construction the wall drains discharge onto the subgrade in front of the wall. Once the wall is completed, the base of the drains should be directed to discharge through weep holes until the permanent drainage system is installed in front of the wall.

Proof tests have been called out and should be performed on a number of test nails that is shown on the attached plans. Proof test nails shall not be production nails but shall be located within the production nail pattern and shall be evenly distributed across the face of the wall. We do not recommend performing nail testing under the bridge footing.

At least 1 successful verification test should be performed in the ESU 3B soil unit into which soil nails are to be installed prior to the installation of production nails. Proof and verification tests on soil nails shall be conducted in accordance with WSDOT Standard Specifications Section 6-15.3(8)A and B.

Section 15-3.4.2.1 of GDM requires the construction of a test pit to evaluate standup time at the excavation face. We recommend the contractor construct one test pit near the location of the verification test. The test pit will need to remain open for at least 24 hours The test pit should be a minimum of 10 feet deep and 15 feet long. Test pit should be constructed outside of the nail zone.

We recommend that temporary casing be used for nails constructed under the bridge footing and be backfilled with nonstructural filler such as Grout Type 4 for Mulitpurpose Applications as shown in the Standard Specificaitons 9-20.3(4).

8.0 GEOTECHNICAL INSTRUMENTATION PLAN

The following bullet points identified in Section 2.6.7.5 requiring geotechnical instrumentation are either not currently proposed under the current work plan or not applicable to the project at the retaining wallscovered in this report:

- Sensitive facilities (none identified in RFP)
- Temporary Shoring (none currently proposed)
- Dewatering operations (none currently proposed)
- Staged embankment construction (not currently proposed)
- Ground structure vibrations during shaft casing or pile driving (no piles or casing currently proposed)
- Vibrations for freshly placed concrete (all concrete currently proposed as precast)

Should unanticipated conditions be encountered, or unanticipated construction means and methods be used that require additional geotechnical instrumentation, we will issue an addendum to this plan.

The soil nail retaining wall is planned to be constructed in front of the existing Pier 1 footing for the 30th Avenue Overcrossing. We recommend that wall facing be surveyed at approximate 50-foot intervals for vertical and horizontal monitoring purposes for the wall. In addition we recommend that the Pier 1 footing be surveyed at the north and south ends for monitoring of vertical and horizontal movement that may result as the proposed wall construction.

Survey information should be forwarded to the GEOR at regular intervals during construction of the walls.

8.1 Alert and Action Levels

This GIP establishes limits of horizontal and vertical movements for alert and action levels for which additional consideration will be given to the construction of the soil nail retaining wall.

Alert Level Soil Nail Wall: Vertical movement of ½ inch. Horizontal movement of 1 inch.

Action Level Soil Nail Wall: Vertical movement of 1 inch. Horizontal movement of 3 inches.

Alert Level Pier 1 Footing: Vertical and horizontal movement of ½ inch.

Action Level Pier 1 Footing: Vertical and horizontal movement of ¾ inch.

At the point observed movement magnitudes reach the indicate values above the EOR, design team, and design-builder will be confer to incorporate the corrective action plan outlined below.

8.2 Corrective Action Plan

The corrective action plan items below shall be implemented in accordance with Sections 2.6.7.1 and 2.6.7.5.1 and will include the following steps:

- Identification of the work areas where the action level has been reached
- Notify the EOR that action levels have been reached and corrective action is necessary
- Provide a revised work plan in consultation with the design team and design-builder
- Provide a revised work plan to the WSDOT Engineer for Review and Comment
- Work in areas where action levels were reached will be halted until the revised work plan has been accepted by the WSDOT EOR
- Identify circumstances where the corrective actions were needed and revise the retaining wall design and/or incorporate revised construction procedures to keep observed settlements below the action levels
- Notify the WSDOT EOR immediately when the observed movement meets or exceeds the allowable settlement and in writing within 24 hours

~~8.0~~9.0 GEOTECHNICAL SPECIAL INSPECTION PLAN

The project technical requirements require continuous construction inspection of soil nail installation and testing by a Geotechnical Special Inspector (GSI) or QA Inspection (QAI) Technician operating under the direction and review of the Geotechnical Engineer of Record. The construction inspection shall be reviewed by the Geotechnical Engineer-of-Record, or their representative, to confirm that subsurface conditions match design assumptions, facing installation conforms to the required reinforcement and shotcrete placement, and soil nail proof and verification tests meet the specified performance criteria.

The following shall be observed, verified and documented by a GSI or a QAI:

- • Types and locations of soil/rock units encountered during construction;
- • Groundwater conditions during drilling; the types of equipment used to drill;
- • The drilling methods used; methods to remove cuttings from the hole, spoil volumes, rates of advancement and daily production rates;
- • Hole stability during construction and the use of casings;
- • Cleanliness of the drill hole;
- • Types, lengths, and dimensions of bars or tendons;
- • Volumes and locations of control density fill (CDF), concrete, and grout placed; and
- • Caving or heave during construction.

The GSI or a QAI shall verify and document compliance of grout types used, mix designs, and batching/mixing equipment; and monitor and record grout pressures and volumes. The report

<u>may be prepared by the GSI or a representative of QA. The GSI shall review the information on a daily basis and the document shall be certified as complete and accurate.</u>

<u>The following field tests shall be performed under the direction of the GSI or a QAI:</u>

- <u>All verification, performance, and proof tests of soil nails (all types) and ground anchors (all types) per article 6-15.3(8) Soil Nail Testing and Acceptance, of the WSDOT (2016) Standard Specification.</u>

- <u>All results of verification, performance and proof tests of soil nails shall be provided to the EOR for review. The EOR will determine final acceptance of each soil nail.</u>

<u>Observance of planned test pit. The purpose of the planned test pit is to evaluate the material properties of the material behind the soil nail wall and to evaluate the stand-up time of the cut when left open. The test pit will be left open for 24 hours in accordance with GDM Section 15.3.4.2.1 Soil Nail Walls. The excavation of the test pit and condition of the cut walls shall be observed by the GSI or representative of the GER.</u>~~Observe service test pit~~

~~9.0~~<u>10.0</u> USE OF THIS REPORT

This geotechnical report has been prepared to support the design of Retaining Wall 6.50L. The analyses and recommendations presented in this report are based on the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

This report has been prepared for the exclusive use of Parsons, FlatIron<u>-Lane</u> JV, and WSDOT and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

~~10.0~~<u>11.0</u> REFERENCES

~~I-405 Renton to Bellevue project conformed Request for Proposal (RFP)~~
~~Appendix G1 GBR20181214~~
~~Appendix G2 GDR20181214~~

~~Appendix G4 ReferenceInfoGeoLandslides20181214~~

~~WSDOT Geotechnical Design Manual (GDM)~~
~~AASHTO LRFD Bridge Design Specifications, 8th edition, 2017 (BDS)~~
~~FHWA GEC No. 3 – Geotechnical Earthquake Engineering~~
~~FHWA GEC No. 7 – Soil Nail Walls Reference Manual~~
~~Project Geotechnical Soil Properties Methodology, FLJV & Wood (GSPM)~~
~~WSDOT Standard Specifications for Road, Bridge, and Municipal Construction.~~ American Association of State Highway and Transportation Officials (AASHTO) (2017). AASHTO LRFD Bridge Design Specifications (8th edition). Washington, DC (BDS)

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Cetin, K. O.; Seed, R. B.; Der Kiureghian, Armen; and others, (2004), Standard penetration test-based probabilistic and deterministic assessment of seismic soil liquefaction potential: Journal of Geotechnical and Geoenvironmental Engineering, v. 130, no. 12, p. 1314-1340.

FHWA (2011). GEC No. 3: LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations.

FHWA (2015). GEC No. 7: Soil Nail Walls Reference Manual.

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Troost, K.G. (2012). Geologic Map of Bellevue, Washington. GeoMap Northwest Production Map. April.

WSDOT (February 1, 2016) I-405/SR16 project Request for Proposal (RFP).
Appendix G4 Reference_Info20181214
Appendix G4 ReferenceInfoBridgeSeismic20181214

WSDOT (December 14, 2018a) Geotechnical Baseline Report, I-405 Renton to Bellevue Widening and Express Toll Lanes Project. XL-4653/XL-5467, I-405, MP 0.0–14.6.

WSDOT (December 14, 2018a) Geotechnical Data Report, I-405 Renton to Bellevue Widening and Express Toll Lanes Project. XL-4653/XL-5467, I-405, MP 0.0–14.6.

WSDOT (December 14, 2018b). General Geologic Characterization and Unstable Slope Evaluation, I-405 Renton to Bellevue Widening and Express Toll Lanes Project.

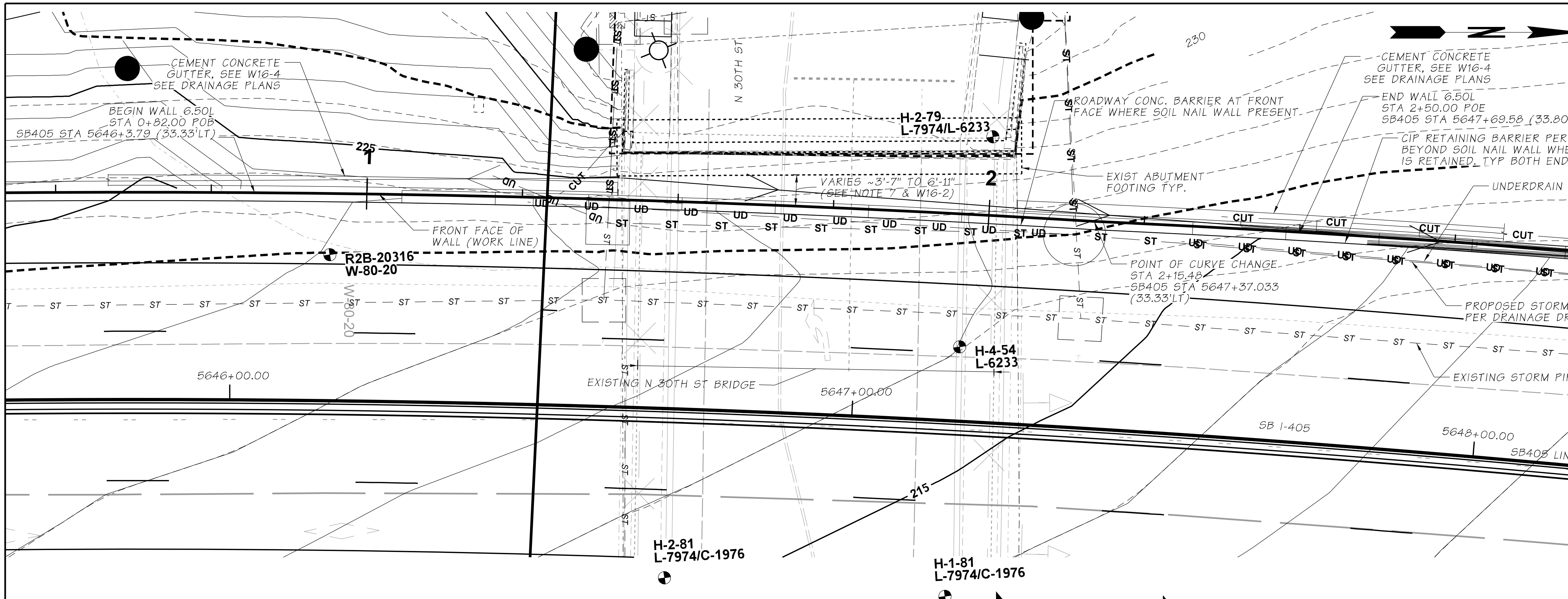
WSDOT (July, 2019a). Geotechnical Design Manual (GDM).

WSDOT (July, 2019b). Bridge Design Manual (GDM).

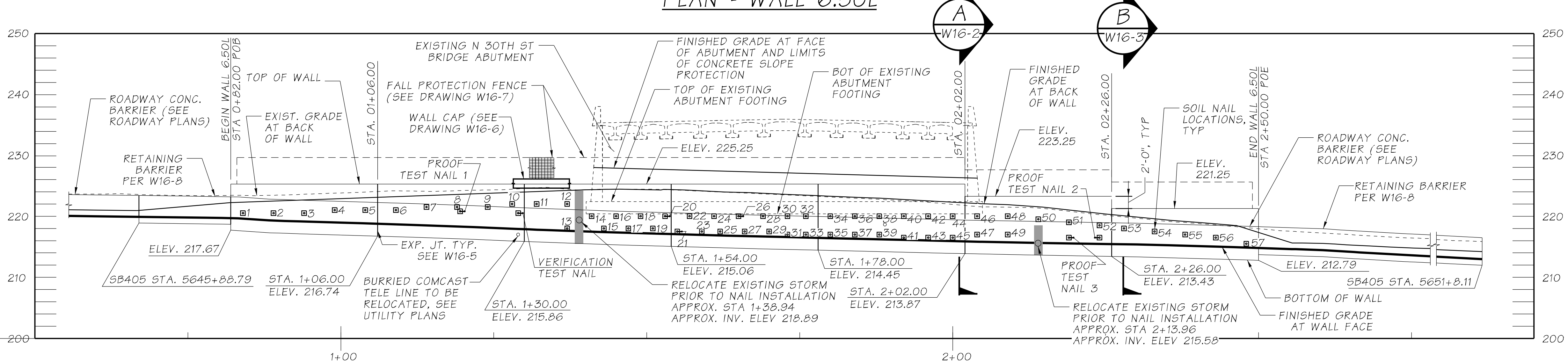
WSDOT (2018c). Standard Specifications for Road, Bridge, and Municipal Construction.

Yount, J.C., J.P. Minard, and G.R. Dembroff. (1993). Geologic Map of Surficial Deposits in the Seattle 30' X 60' Quadrangle, Washington. USGS Open-File Report 93-233.

APPENDIX A
RETAINING WALL PLANS



PLAN - WALL 6.50L



ELEVATION - WALL 6.50L

NOTES

1. SEE W16-3 FOR SOIL NAIL SCHEDULE.
2. WALL CONCRETE FACING SHALL BE 6" SIN WAVE SURFACE TEXTURE PER DRAWING W16-4.
3. CONCRETE WALL FACING COLOR SHALL BE MT. ST. HELENS GRAY PIGMENTED SEALER
4. AP INDICATES WALL ANGLE POINT
   POB INDICATES POINT OF BEGINNING
   POE INDICATES POINT OF END
5. ▣ INDICATES SOIL NAIL LOCATION
6. ▦ INDICATES BLACK VINYL COATED CHAIN LINK FENCE PER DRAWING W16-7.
7. CONTRACTOR SHALL FIELD VERIFY LOCATION AND THICKNESS OF EXISTING BRIDGE FOOTING.
8. TOP OF WALL SEGMENTS ARE LEVEL.
9. INSTALL ALL SOIL NAILS AT 15° DECLINATION ANGLE.
10. WALL LAYOUT STATIONING IS PROVIDED AS OFFSET FROM SB I-405 LINE.
11. SEE SHEETS AL-24, RS-32 & RS-8, PR-67, AND PV-24 FOR ROADWAY ALIGNMENT, SECTION, PROFILE, PAVING, AND BARRIER, RESPECTIVELY.
12. SEE TRAFFIC CONTROL PLAN SEGMENT 1B SHEET MOT-24, STAGE 4, PHASE 2 FOR WORK ZONE AND TRAFFIC STAGE.
13. SEE SHEETS TC-909 THRU TC-911 FOR I-405 SB SINGLE & DOUBLE RIGHT LANE CLOSURE AND RFP 2.22.4.3.1.2 FOR I-405 SOUTHBOUND ALLOWABLE MAINLINE (LANES)CLOSURE HOURS
14. SEE SHEETS DSP-24 & DR-24 FOR DRAINAGE SITE PREPRATION AND DRAINAGE PLAN, RESPECTIVELY.
15. SEE SHEET TS-24 FOR ITS AND TOLL PLAN.

DATUM (NAVD) 88

0 10 20 SCALE IN FEET

WALL 6.50L ALIGNMENT COORDINATES

STATION	NORTHING	EASTING
0+00.00	191931.75	1303029.79
0+18.55	191950.30	1303029.47
1+98.68	192130.36	1303032.73
2+35.07	192166.70	1303034.67
3+07.76	192232.22	1303039.59
4+00.06	192331.21	1303047.15

WALL 6.50L CURVE DATA

P.I. STATION	DELTA	RADIUS	TANGENT	LENGTH
1+08.65	04°3'36" RT	2545.00'	90.10'	180.13'
2+71.42	01°38'24" RT	2547.00'	36.35'	72.69'

FILE NAME	c:\pw_working\wastate\parsons_p005295d\dms32767\XL5467_DE_W16-1.dgn
TIME	3:39:16 PM
DATE	11/23/2021
PLOTTED BY	p005295D
DESIGNED BY	N. ALA
ENTERED BY	M. ALEKSANYAN
CHECKED BY	E. KELLEY
PROJ. ENGR.	J. LEFOTU
REGIONAL ADM.	L. HODGSON

REVISION | DATE | BY

REGION NO. 10 | STATE WASH | FED.AID PROJ.NO.

JOB NUMBER XL5467

CONTRACT NO. C9242 | LOCATION NO.

ERIC R. KELLEY — STATE OF WASHINGTON — 44060 — STRUCTURAL PROFESSIONAL ENGINEER

P.E. STAMP BOX DATE

P.E. STAMP BOX DATE

Washington State Department of Transportation

FLATIRON LANE

PARSONS

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND PROFILE WALL 6.50L

PLAN REF NO W16-1

SHEET OF SHEETS

APPENDIX B
BORING LOGS

H-2-79

1980b WSDOT NE 30th Uxing

HWY Form 351-003 (H. F. 26.66)
(Revised 5-67).

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to

LOG OF TEST BORING

S.H. S.R. 405 Section SR-169 O-xing to SR-90 O-xing Job No. L-6233
Hole No. H-2 Sub Section N.E. 30th St. U-xing Replacement Cont. Sec. 1744
Station 0+80 W Offset 28' N, ℄ Ground El. 224'
Type of Boring Jet and Chop Casing 3" I.D., -47.0' W.T. El. See bottom, Sheet 3
Inspector James D. Lance Date Dec. 18, 1979 Sheet 1 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			3 STD	Sod.
	9		4 PEN	Dark brown organic, sandy clayey SILT.
			5	Loose, brown, gravelly silty SAND.
			8 1	
			11 STD	
	27		13 PEN	Dense, brown, silty, fine to medium grained SAND - moist.
			14	
			16 2	
5				
			18 STD	
	40		21 PEN	Dense, light brown, silty, fine to medium grained SAND - moist.
			19	
			21 3	
10				
			23 STD	
	64		31 PEN	Very dense, brown, silty, fine to medium grained SAND - moist.
			33	
			37 4	
15				
			20 STD PEN	Dense, brown, silty, moist, fine to medium grained SAND - piece
	47		24	of fine gravel in top of sample.
			23 5	
			20	
20				

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

1980b WSDOT NE 30th Uxing

Hole No. H-2 Sub Section N.E. 30th St. U-xing Replacement Sheet 2 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			U-6	No Recovery - Lost Ball Valve.
25	19		10 10 9 11 STD PEN 7	Medium dense, brown, moist, very silty fine SAND - with a trace of medium to coarse sand.
			A B C U-8	Very stiff, light brown, fine sandy SILT - contains fine gravel.
	12		5 6 6 6 STD PEN 9	Stiff, light brown, fine sandy SILT - with thin lenses of rust brown silt, moist.
30				
	66		14 17 49 127 STD PEN 18	Very hard, light brown, moist, fine sandy SILT - contains gravel.
35				
	151		65 47 104 STD PEN 11	Very dense, brown, moist, very silty, fine to coarse SAND - with gravel (Glacial Till).
40				
	164		58 106 STD PEN 12	Very dense, light brown, slightly silty, fine to medium grained SAND - moist.
45				

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

1980b WSDOT NE 30th Uxing

Hole No. H-2 Sub Section N.E. 30th St. U-xing Replacement Sheet 3 of 3

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
47				
	195/10"		95/100 4" STD PEN 13	Very dense, brown, moist, very silty, fine to coarse SAND - with gravel (Glacial Till).
				TEST BORING STOPPED AT -47.9' BELOW GROUND ELEVATION.
				WATER LEVEL READING MADE WHILE PULLING CASING: -32.0'.

H-2-81

1980b WSDOT NE 30th Uxing

F 26-66 (Rev. 5-67)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Engineer
Copy to

LOG OF TEST BORING

S.H. S.R. 405 Section NE 30th U/C STRUCTURE Job No. C-1976
Hole No. 2 Sub Section Pie 2 Cont. Sec.
Station SR 405 408+56 Offset 7.5' LT. Ground El. 211.3'
Type of Boring Augers Casing 10" X 17.5' W.T. El. -6.0'
Inspector D.J. Date 3-4-81 Sheet 1 of 1

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
0				
				FOOTING EL. 205.0'
5			1.0' Rec.	O.G.
	P-1 16		4 8 8 10	SAND: grey, fine, SILTY damp
			1.7' Rec.	SATURATED -6.0' TO -10.5'
	P-2 16		5 7 9 8	
10			1.8' Rec.	SILT: br. sandy, occ. piece of fine
	P-3 10		4 4 6 8	gravel. Wet TO -10.5' Then Damp.
			1.8' Rec.	
	P-4 12		5 6 6 7	very sandy
15			1.7' Rec.	oxidized -15.5' TO -15.9'
19	P-5 57		13 33 24 42	SAND: br. f. TO C. gravelly SILTY
			1.8' Rec.	DAMP (Lightly Cemented)
	P-6 78		17 33 45 72	
				W.E. after pulling Augers -6.0'

wood.
4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-80-20
CLIENT WSDOT **PROJECT LOCATION** Renton, WA
DATE STARTED 6/4/20 **COMPLETED** 6/4/20 **GROUND ELEVATION** 219.6 ft NAVD88 **HOLE SIZE** 8 inches
DRILLING CONTRACTOR Gregory Drilling **DRILL RIG** CME 55 ID: #310 **SPT HAMMER EFFICIENCY** 80%
DRILLING METHOD HSA **STATION (FT)** 5646+15.75 **OFFSET (FT)** 23.5 L
LOGGED BY Chris Lopez **CHECKED BY** H. Brenniman **NORTHING** 192025.752 **EASTING** 1303039.126
NOTES **GW LEVEL (ATD)** Dry

ELEVATION (ft)	DEPTH	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE	MC / PL / LL / FINES CONTENT (%)	TESTS AND REMARKS
	0	Poorly graded SAND with silt, medium dense, yellowish brown, moist, [Fill] (SP)					
			44	SPT-1 6 8 10	18		
215	5		56	SPT-2 6 10 11	21	MC ●	MC = 6%
		Becomes loose	78	SPT-3 5 6 4	10		
210		Silty CLAY, loose, yellowish brown to brown, moist to wet, [Qvr] (CL-ML)					
	10		89	SPT-4 3 3 4	7	PL–MC ● □	MC = 30% LL = 29 PL = 24 Fines = 92%
				ST-1			
		Sandy SILT, dense, yellowish brown, moist, [Qvt] (ML)					
205	15		100	SPT-5 11 14 18	32	MC ● □	MC = 14% Fines = 54%
		Becomes very dense					Harder drilling at 17.5 feet
200	20						

(Continued Next Page)

wood.
4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-80-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft)	DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80	TESTS AND REMARKS
	20		Sandy SILT, dense, yellowish brown, moist, [Qvt] (ML) *(continued)*	57	SPT-6 43 50/1"	50/1"	

Bottom of borehole at 20.6 feet.

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APPENDIX C
CALCULATIONS

PROJECT: I-405 Renton to Bellevue Widening and ETL	Page ____ of ____
JOB NO. 81215044 Date November 2021 Comp. By YY	CHECKED BY: pjp

Appendix C Report Section 1 and 2

Retaining Wall ID	6.50L
Type	Special Barrier/Soil Nail Wall
Begin Soil Nail Wall	SB405 STA 5646+03.79 (33.33' LT)- Wall STA 0+82.00
End Soil Nail Wall	SB405 STA 5647+69.58 (33.80' LT)-Wall STA 2+50.00
Soil Nail Wall Height (ft)	3.6 to 7.3
Soil Nail Wall Length (ft)	165
Special Design Barrier	North and South ends of soil nail wall, limits shown on roadway plans
Special Design Barrier Max Height (ft)	Up 3.5
Existing Borings	H-2-79, H-2-81, W-80-20

Appendix C Report Section 3

ESU assigned based on the following borings.

TABLE 2 –BORING SUMMARY

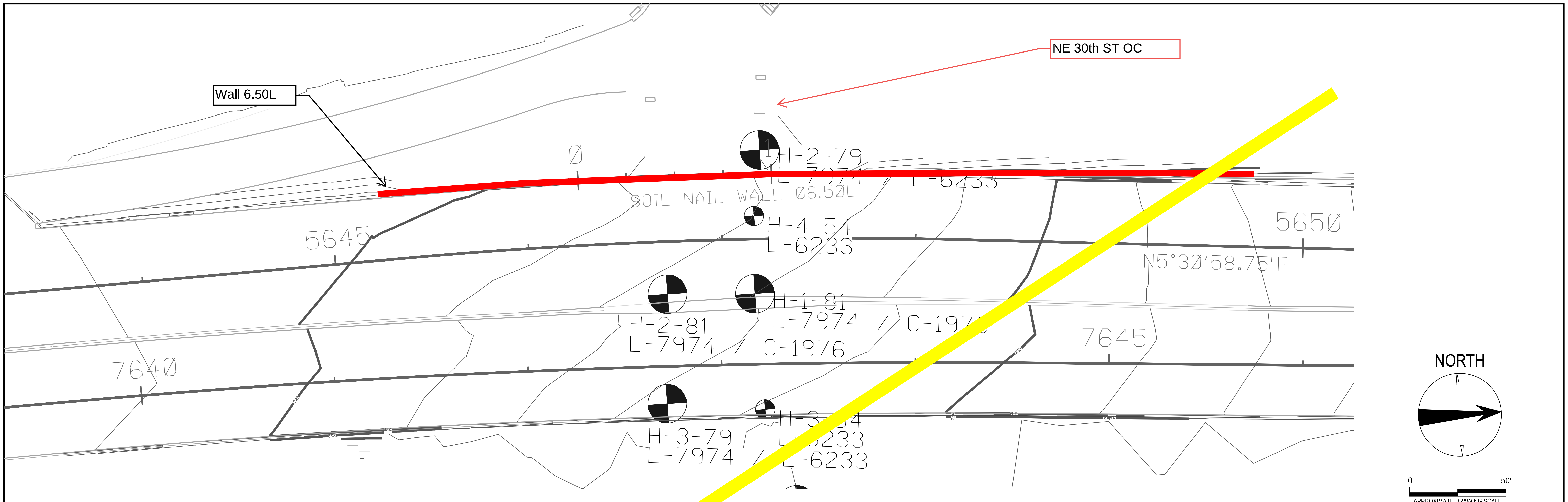
Boring Number	Date Completed	Boring Depth (ft)	Ground Surface Elevation (ft. MSL)[1]	Groundwater Elevation (ft. MSL)
W-80-20	6/4/2020	[illegible].6	219.6	Dry
H-2-79	12/18/1979	[illegible]7.9	224	192
H-2-81	3/7/1981	20	211.3	205.3

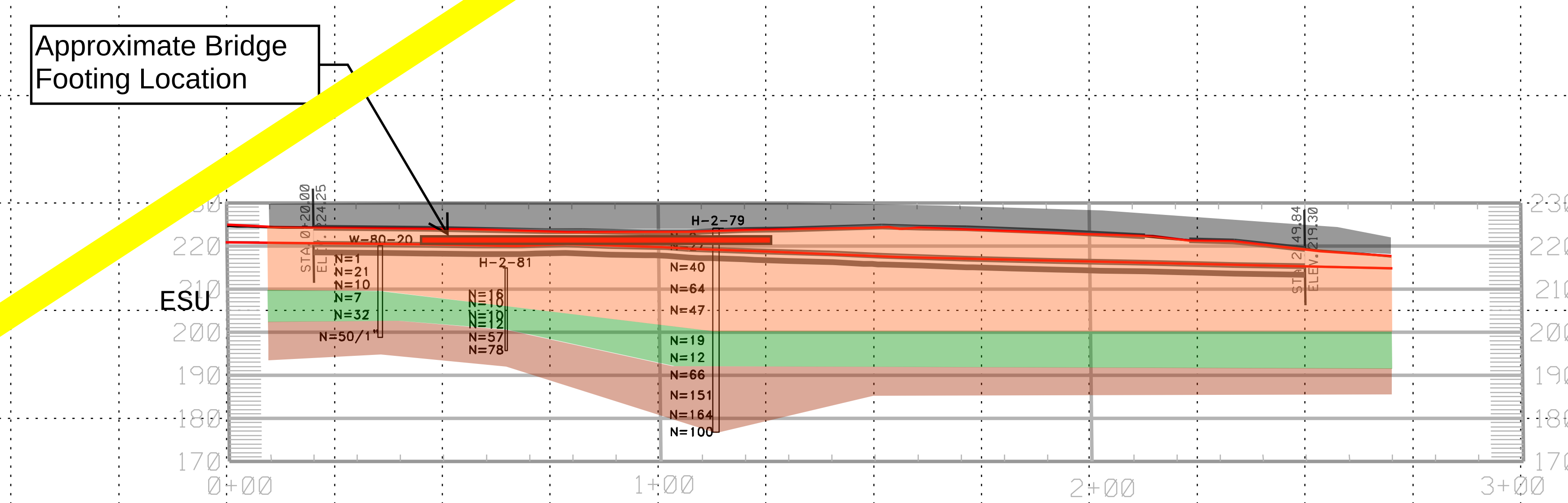
Notes:

1. Ground water assumed at EL=209 feet for design.

Wall Profile with ESU on following page.

ESU-Note, Only ESU 3B used for Wall Design
ESU 1 and 3B as overburden





Only 3B used in analyses

ESU CLASSIFICATION					DESIGN SOIL PROPERTIES FOR ANALYSIS				
ESU GROUP		SOIL MATERIAL				DRAINED CONDITION		UNDRAINED CONDITION	
COLOR	ESU #	DESCRIPTION	DENSITY/CONSISTENCY	PRIMARY CONSTITUENT	UNIT WEIGHT (pcf)	FRICTION ANGLE (deg)	Su'(psf)	FRICTION ANGLE (deg)	Su (psf)
	1B	UNCONTROLLED FILL	MEDIUM DENSE TO DENSE	SAND AND GRAVEL	125	35	50	35	200
	3B	RECESSIONAL OUTWASH	MEDIUM DENSE TO VERY DENSE	SAND	125	36	0	36	0
	3E	LACUSTRINE	STIFF TO VERY STIFF	SILT / CLAY	120	32	50	0	1500
	4C	GLACIAL TILL	DENSE TO VERY DENSE	SILTY SAND AND GRAVEL	135	40	200	40	200

No short term loading considered

ESU PROFILE
Wall 6.50L

SHEET X OF X

Terracon

CONT	SECT	JOB	HIGHWAY
C	S	J	HWY

DIST	COUNTY	SHEET NO.
DST	CTY	AA

SYSTEMTIME SYSTEMDATE USERNAME DGNSPEC

Appendix C Report Section 4 Seismic Design

TABLE 3 - SEISMIC DESIGN PARAMETERS

Parameter	Value
Site Class	D
Peak Ground Acceleration (PGA)	0.425g
FPGA	1.175
Site-Adjusted Peak Ground Acceleration (AS)	0.50
Mean Magnitude Earthquake (Mw)	7

Determination of As

The site adjusted seismic acceleration, As, was determined in accordance with GDM Chapter 6 as shown in the attached analysis. A site peak ground acceleration, PGA, of 0.433g and an earthquake magnitude of 7 were developed for the wall location. Based on observed soil conditions a Site Class D was assigned and the PGA adjusted per the following table:

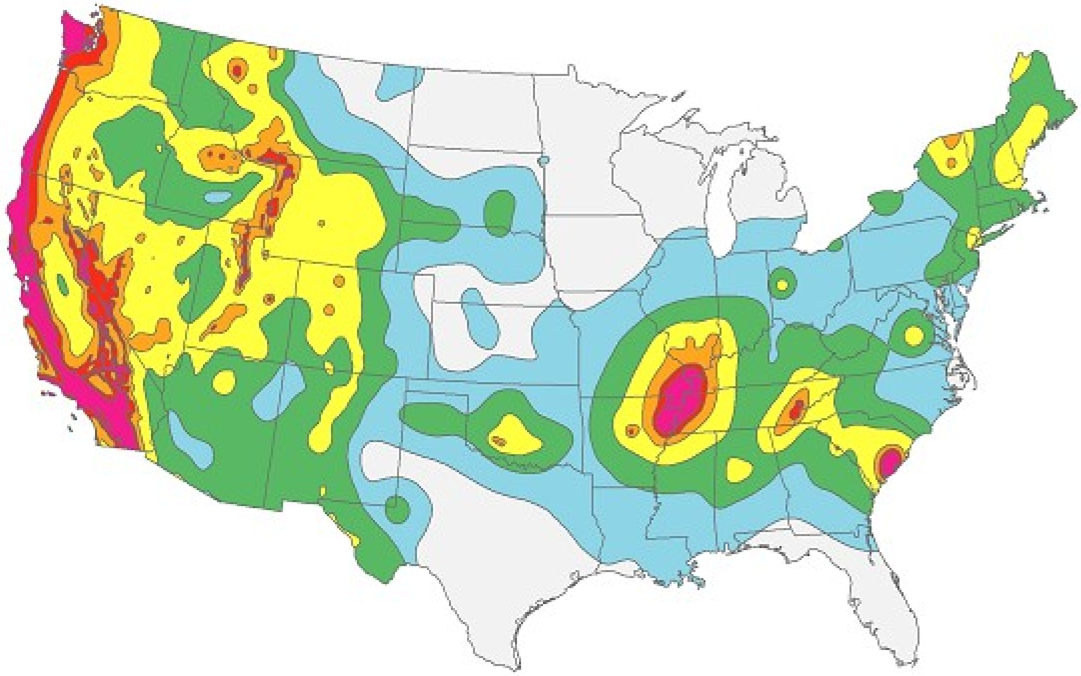
No liquefaction assumed due to depth to groundwater and cohesive soils below wall.

Spectra output and Site Class calcs on following pages.

BEToolbox™

Spectra

Version 6.1.0 - Built on May 12 2021



WSDOT Bridge Design Manual
2014 Seismic Hazard Map, 7% probability of exceedance in 75 years

Site Coordinates (Latitude,Longitude): 5e+01° N, 1e+02° W
Site Soil Classification: Site Class D - Stiff Soil

Seismic hazard maps are for sites at the boundary of Site Classes B and C, which is $\bar{v}_s$ = 2500 ft/s (760 m/s). Adjustments for other Site Classes are made as needed.

Period (sec)	Sa (g)	
0.0	0.433	PGA - Site Class B/C Boundary
0.2	0.987	S_s - Site Class B/C Boundary
1.0	0.283	S_1 - Site Class B/C Boundary

Values of Site Coefficient, F_{pga}, for Peak Ground Acceleration

Site Class	Mapped Peak Ground Acceleration Coefficient (PGA)					
	PGA≤ 0.10	PGA= 0.20	PGA= 0.30	PGA= 0.40	PGA= 0.50	PGA≥ 0.60
A	0.8	0.8	0.8	0.8	[illegible]	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1

For Site Class D, F_{pga} = 1.167

Values for Site Coefficient, F_a, for 0.2 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 0.2 sec (S_s)					
	S_s≤ 0.25	S_s= 0.50	S_s= 0.75	S_s= 1.00	S_s= 1.25	S_s≥ 1.50
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	[illegible]	0.9	0.9	0.9
C	1.3	1.3	[illegible]	1.2	1.2	1.2
D	1.6	1.4	[illegible]	1.1	1.0	1.0
E	2.4	1.7	1.3	1.0	0.9	0.9

For Site Class D, F_a = 1.105

Values of Site Coefficient, F_v, for 1.0 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 1.0 sec (S_1)					
	S_1≤ 0.1	S_1= 0.2	S_1= 0.3	S_1= 0.4	S_1= 0.5	S_1≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	[illegible]	1.5	1.5	1.5	1.5	1.4
D	[illegible]	2.2	2.0	1.9	1.8	1.7
E	[illegible]	3.3	2.8	2.4	2.2	2.0

For Site Class D, F_v = 2.033

$A_s = F_{pga}$ PGA = (1.167)(0.433g) = 0.505g
$S_{DS} = F_a S_s$ = (1.105)(0.987g) = 1.090g
$S_{D1} = F_v S_1$ = (2.033)(0.283g) = 0.576g
$T_o = 0.2T_s$ = (0.2)(0.528) = 0.106 sec
$T_s = S_{D1}/S_{DS}$ = (0.576)/(1.090) = 0.528 sec

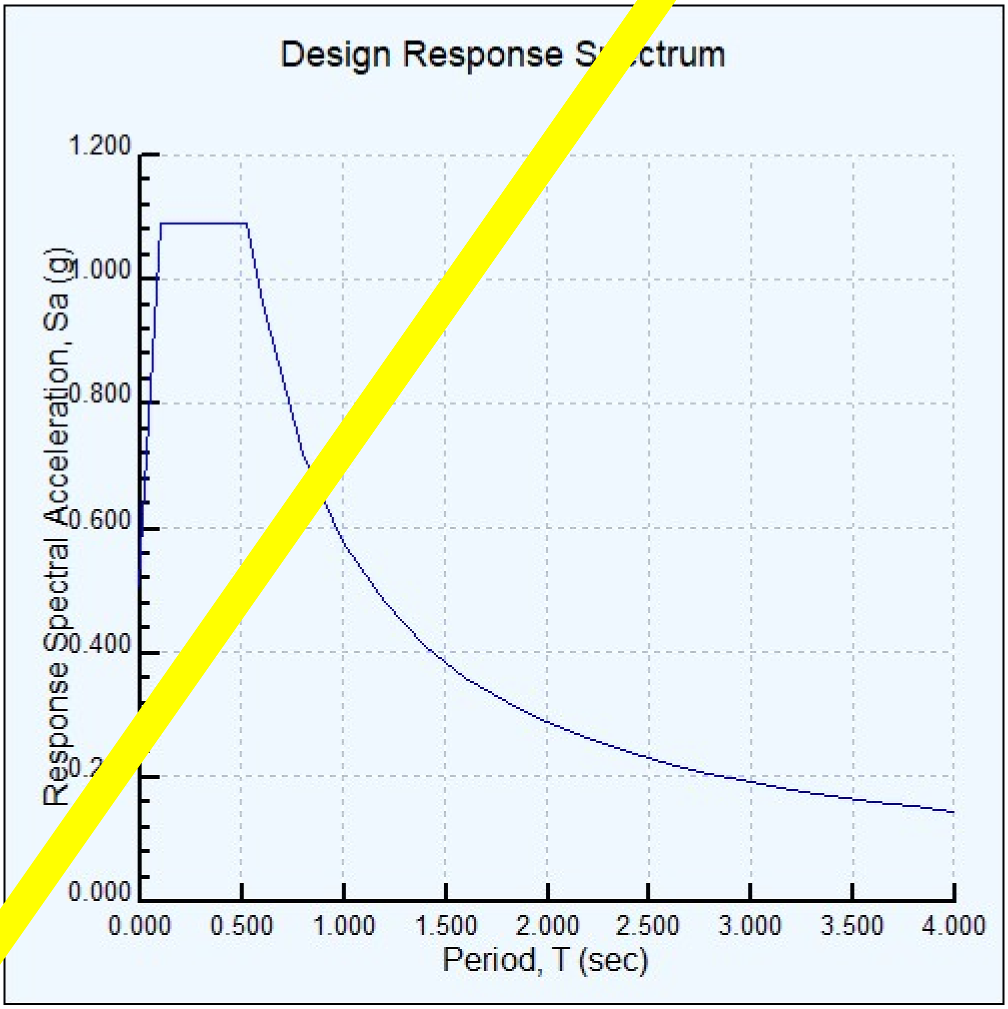
Partitions for Seismic Design Categories A, B, C, and D

S_{D1}	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

As for Site Class D

Seismic Design Category (SDC) = D

Period, T (sec)	Sa (g)	
0.000	0.505	
0.106	1.090	T_o
0.200	1.090	
0.400	1.090	
0.528	1.090	T_s
0.600	0.960	
0.800	0.720	
1.000	0.576	
1.200	0.480	
1.400	0.412	
1.600	0.360	
1.800	0.320	
2.000	0.288	
2.200	0.262	
2.400	0.240	
2.600	0.222	
2.800	0.206	
3.000	0.192	
3.200	0.180	
3.400	0.169	
3.600	0.160	
3.800	0.152	
4.000	0.144	



Project Name	Renton To Bellevue
Project Number	81215044
Structure Number	Wall 6.50
Boring	H-2-79
Date	10/28/2021

Sample Number	Sample Top Depth	Sample Bottom Depth	Midpoint of Layer	Layer Thickness, d_i	N1	N2	N3	Uncorrect N Value, N_i	d_i/N_i
1	0	1.5	0.75	0.75				9	0.08
2	2	3.5	2.75	2				27	0.07
3	7	8.5	7.75	5				40	0.13
4	12	13.5	12.75	5				64	0.08
5	17	18.5	17.75	5				47	0.11
6	24	25.5	24.75	7				19	0.37
7	28	29.5	28.75	4				12	0.33
8	32.5	34	33.25	4.5				66	0.07
9	37	38.5	37.75	4.5				97	0.05
10	42.5	43.5	43	5.25				100	0.05
11	47	48	47.5	4.5				100	0.05

NOTE: Boring Extends to 48 ft bgs

Sum Check   Check Your Answer

Average N	34
Site Class	D

Table 3.10.3.1-1—Site Class Definitions

Site Class	Soil Ty[illegible] Profile
A	Hard rock with measured shear wave velocit[illegible]5,000 ft/s
B	Rock with 2,500 ft/sec < $\bar{v}_s$ < 5,000 ft/s
C	Very dense soil and soil rock with 1,2[illegible]ec < $\bar{v}_s$ < 2,500 ft/s, or with either $\bar{N}$ > 50 blows/ft, o[illegible] 2.0 ksf
D	Stiff soil with 600 ft/s < $\bar{v}_s$ < [illegible]t/s, or with either 15 < $\bar{N}$ < 50 blows/ft, or 1.0 < $\bar{s}_u$ < 2.0 ksf
E	Soil profile with $\bar{v}_s$ < [illegible]s or with either $\bar{N}$ < 15 blows/ft or $\bar{s}_u$ < 1.0 ksf, or any profile with more than 10 ft of soft c[illegible]ned as soil with $PI > 20$, $w > 40$ percent and $\bar{s}_u$ < 0.5 ksf
F	Soils requirin[illegible]ecific evaluations, such as: • Peat[illegible]ghly organic clays ($H > 10$ ft of peat or highly organic clay where H = thickness of soil) • V[illegible]gh plasticity clays ($H > 25$ ft with $PI > 75$) • [illegible] thick soft/medium stiff clays ($H > 120$ ft)

Method B: $\bar{N}$ method

The average $\bar{N}$ for the top 100 ft shall be determined as:

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

where:

N_i = Standard Penetration Test blow count of a layer (not to exceed 100 blows/ft in the above expression)

Project Name	Renton To Bellevue
Project Number	81215044
Structure Number	Wall 6.50
Boring	W-80-20
Date	10/28/2021

Sample Number	Sample Top Depth	Sample Bottom Depth	Midpoint of Layer	Layer Thickness, d_i	[illegible]1	N2	N3	Uncorrect N Value, N_i	d_i/N_i
1	2.5	4	3.25	3.25				18	0.18
2	5	6.5	5.75	2.5				21	0.12
3	7.5	9	8.25	2.5				10	0.25
4	10	11.5	10.75	2.[illegible]				7	0.36
5	15	16.5	15.75	[illegible]				32	0.16
6	20	20.5	20.25	4.5				93	0.05

NOTE: Boring Extends to 20.5 ft bgs

Sum Che[illegible] Check Your Answer

Average N	18
Site Class	D

Table 3.10.3.1-1—Site Class Definitions

Site Class	Soil Type and Profile
A	Hard rock with measured shear wave velocity, $\bar{v}_s > 5{,}000$ ft/s
B	Rock with 2,500 ft/sec < $\bar{v}_s$ < 5,000 ft/s
C	Very dense soil and soil rock with 1,200 ft/sec < $\bar{v}_s$ < 2,500 ft/s, or with either $\bar{N}$ > 50 blows/ft, or $\bar{s}_u$ > 2.0 ksf
D	Stiff soil with 600 ft/s < $\bar{v}_s$ < 1,200 ft/s, or with either 15 < [illegible]0 blows/ft, or 1.0 < $\bar{s}_u$ < 2.0 ksf
E	Soil profile with $\bar{v}_s$ < 600 ft/s or with either $\bar{N}$ < [illegible]s/ft or $\bar{s}_u$ < 1.0 ksf, or any profile with more than 10 ft of soft clay defined as soil with PI > [illegible] 40 percent and $\bar{s}_u$ < 0.5 ksf
F	Soils requiring site-specific evaluations, su[illegible] • Peats or highly organic clays (H [illegible]of peat or highly organic clay where H = thickness of soil) • Very high plasticity clays (H [illegible] with PI > 75) • Very thick soft/medium sti[illegible] (H >120 ft)

Method B: $\bar{N}$ method

The average $\bar{N}$ for the top 100 ft shall be determined as:

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

where:

N_i = Standard Penetration Test blow count of a layer (not to exceed 100 blows/ft in the above expression)

Project Name	Renton To Bellevue
Project Number	81215044
Structure Number	Wall 6.50
Boring	H-2-81
Date	10/28/2021

Terracon

Sample Number	Sample Top Depth	Sample Bottom Depth	Midpoint of Layer	Layer Thickness, d_i	N1	N2	N3	Uncorrect N Value, N_i	d_i/N_i
1	5	6.5	5.75	5.75				16	0.36
2	8	9.5	8.75	3				16	0.19
3	10	11.5	10.75	2				10	0.20
4	13	14.5	13.75	3				12	0.25
5	15	16.5	15.75	2				57	0.04
6	18	19.5	18.75	3				78	0.04

NOTE: Boring Extends to 19.5 ft bgs

Sum Check — Check Your Answer

Average N	18
Site Class	D

Table 3.10.3.1-1—Site Class Definitions

Site Class	Soil Type and Profile
A	Hard rock with measured shear wave velocity, $\bar{v}_s > 5{,}000$ ft/s
B	Rock with 2,500 ft/sec < $\bar{v}_s < 5{,}000$ ft/s
C	Very dense soil and soil rock with 1,200 ft/sec < $\bar{v}_s < 2{,}500$ ft/s, or with either $\bar{N} > 50$ blows/ft, or $\bar{s}_u > 2.0$ ksf
D	Stiff soil with 600 ft/s < $\bar{v}_s < 1{,}200$ ft/s, or with either $15 < \bar{N} < 50$ blows/ft, or $1.0 < \bar{s}_u < 2.0$ ksf
E	Soil profile with $\bar{v}_s < 600$ ft/s or with either $\bar{N} < 15$ blows/ft or $\bar{s}_u < 1.0$ [illegible] any profile with more than 10 ft of soft clay defined as soil with $PI > 20$, $w > 40$ percent and [illegible].5 ksf
F	Soils requiring site-specific evaluations, such as: • Peats or highly organic clays ($H > 10$ ft of peat or highly or[illegible] clay where H = thickness of soil) • Very high plasticity clays ($H > 25$ ft with $PI > 75$) • Very thick soft/medium stiff clays ($H > 120$ ft)

Method B: $\bar{N}$ method

The average $\bar{N}$ for the top 100 ft shall be determined as:

$$\bar{N} = \frac{\sum_{i=1}^{n} d_i}{\sum_{i=1}^{n} \frac{d_i}{N_i}}$$

where:

N_i = Standard Penetration Test blow count of a layer (not to exceed 100 blows/ft in the above expression)

Appendix C Report Section 5 Design Soil Properties

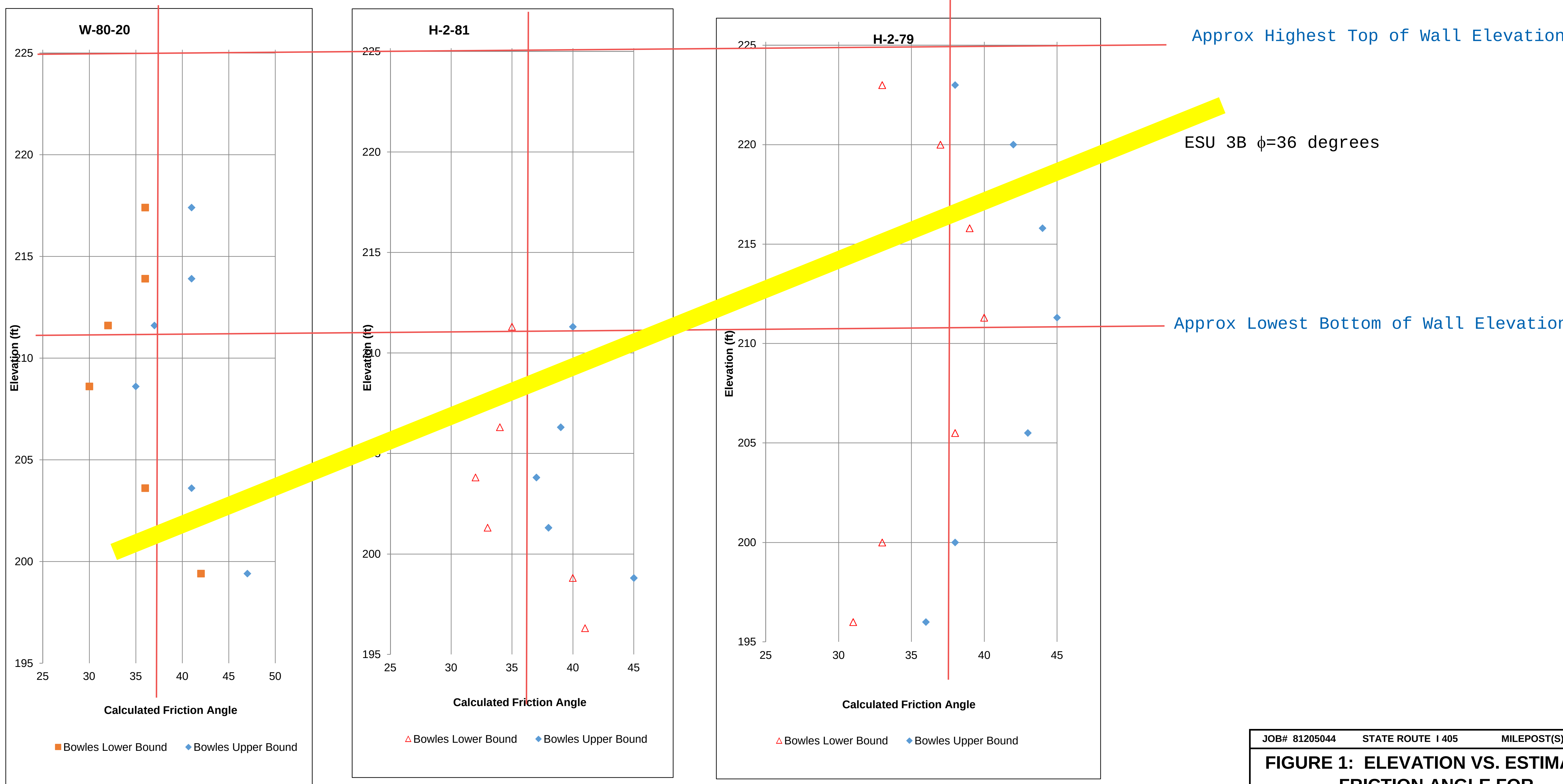
Subsurface soil profiles for the wall alignment as well as several cross sections were developed for analysis of the planned soil nail wall. Soil parameters for design were established using correlations from SPT methodology outlined in the project Geotechnical Soil Properties Methodology (GSPM) contract document. Developed ESU cross sections are included in this calculations package as well as recommended soil properties for design.

ESU Groupings:
ESU Group 1 – Fill materials, either new fill engineered fills or existing fills observed
ESU Group 3 – Recent deposits not containing organics such as alluvium, recessional outwash, or lacustrine deposits

Soil Parameter Development
Applicable boring explorations near the wall location have been reviewed in accordance with the methods explained in the GSPM. USCS soil types of GW, GP, GM, GC, SW, SP, SM, SC and ML soils with little to no plasticity have been assigned internal friction angles according to the figure below and assigned within the range according to their soil type and guidance provided in the WSDOT GDM Section 5.8.3 and by Wood in the table of ESU reviewed by Terracon.
Friction angle based Bowles middle range is shown of the following sheets.

DESIGN SOIL PROPERTIES

ESU	Moist Unit Weight (PCF)	DRAINED CONDITION		UNDRAINED CONDITION	
		Friction Angle (degrees)	Cohesion (PSF)	Friction Angle (degrees)	Su[i] (PSF)
1B	125	35	50	35	200
3B	125	36	0	36	0
3E	120	32	50	0	1500
4C	135	40	200	40	200
Wall profile lies entirely within ESU 3B					



NOTES:
1. Blowcounts used for ϕ value estimation were corrected for hammer energy and overburden pressure.
2. Bowles correlation between ϕ and $N1_{60\ per}$ GDM (2017) was used to estimate drained friction angle of granular material.
3. Terzaghi was used to estimate drained friction angle for fine grained soils,
4.
5.

JOB# 81205044 STATE ROUTE I 405 MILEPOST(S) XX-XX

FIGURE 1: ELEVATION VS. ESTIMATED FRICTION ANGLE FOR

RTB
WALL 7.46L

Terracon Seattle, WA

PREPARED BY MAK DATE Nov 2021

Appendix C Report Section Analyses and Recommendations

Global & Compound Stability:

The software Slide2 by Rocscience. was used for these analyses. Minimum factor of safety is 1.3 (resistance factor of 0.75) in the static case and 1.1 in the seismic (pseudo-static) case per Chapter 15 of the WSDOT GDM and Appendix G updates.

We assumed the following:

- Live Load traffic surcharge was taken to be 2[illegible] psf for static conditions
- For pseudostatic analysis the horizontal seismic acceleration coefficient is assumed to be 50 percent of As per GDM 15-4.10:

$k_h = 0.5 * As = 0.5 * 0.5g =$ **0.25g**

Results are summarized below. Slide2 output prints are attached.

FACTORS OF SAFETY FOR GLOBAL STABILITY

Station	Static Factor of Safety	Pseudo-Static Factor of Safety
1+39.5	1.5	1.1
1+54	1.6	1.1
2+05	1.5	1.1
2+07	1.6	1.1

SOIL NAIL DESIGN STA 0+82 to 1+39

Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
12	5	21	21
1. Single row of nails in this section are #6, 75 KSI			

SOIL NAIL DESIGN STA 1+39 to 2+05

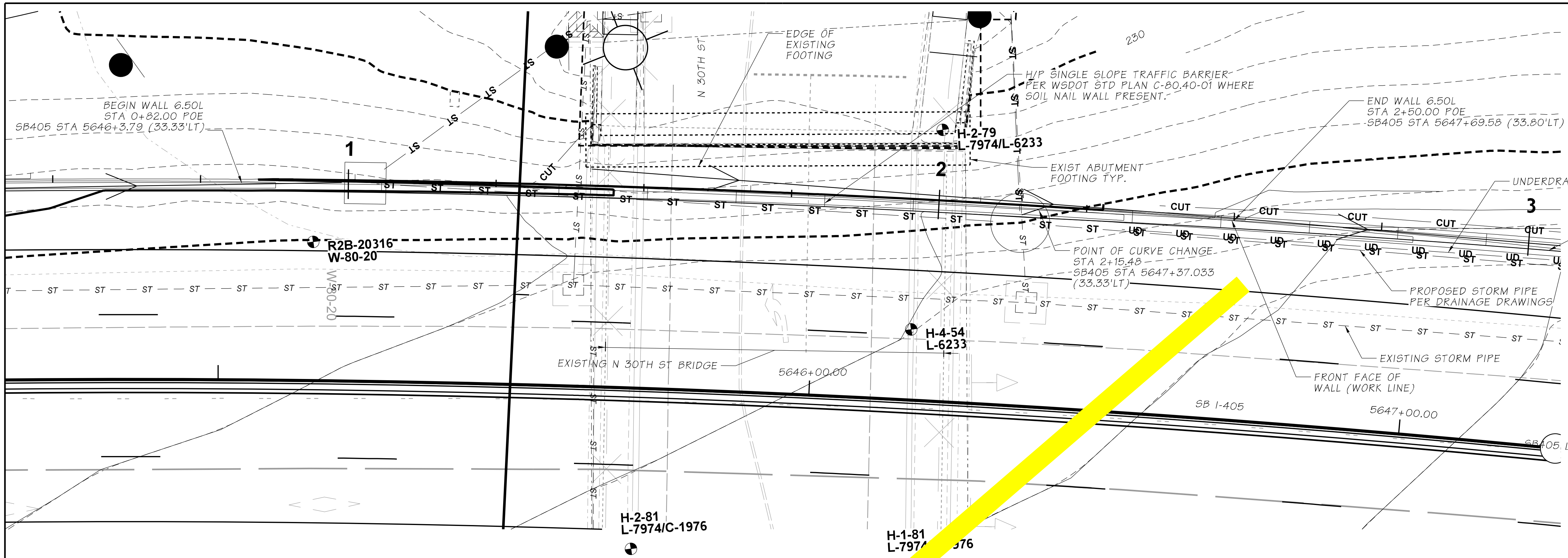
Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
20	4	45	45

1. Two rows of nails, rectangular patter in this section are #10, 75 [illegible]
2. Use nonstructural filler under bridge footing (unbonded zone)
3. Double corrosion protection required

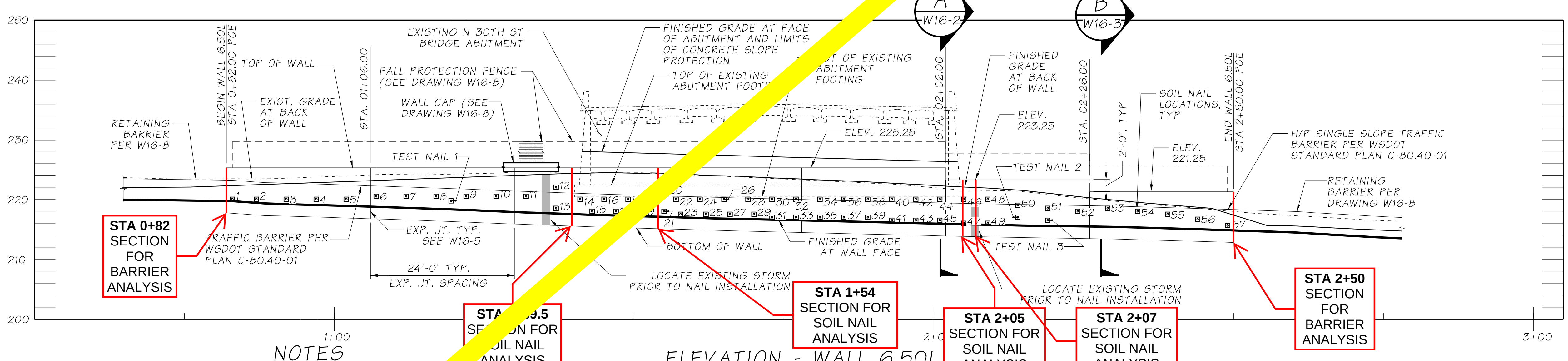
SOIL NAIL DESIGN STA 2+05to 2+50

Minimum Nail Length (FT)	Horizontal Spacing (FT)	STATIC	SEISMIC
		Nail Head Load at Face (KIPS)	Nail Head Load at Face (KIPS)
12	5	17	17

1. Single row of nails in this section are #6, 75 KSI



PLAN - WALL 6.50L



ELEVATION - WALL 6.50L

NOTES

1. WALL CONCRETE FACING SHALL BE 6" SIN WAVE SURFACE TEXTURE PER DRAWING W16-4.
2. CONCRETE WALL FACING COLOR SHALL BE MT. ST. HELENS GRAY PIGMENTED SEALER
3. AP INDICATES WALL ANGLE POINT
   POB INDICATES POINT OF BEGINNING
   POE INDICATES POINT OF END
4. ⊡ INDICATES SOIL NAIL LOCATION
5. ▦ INDICATES BLACK VINYL COATED CHAIN LINK FENCE PER DRAWING W16-7.
6. CONTRACTOR SHALL FIELD VERIFY LOCATION OF EXISTING BRIDGE FOOTING.
7. TOP OF WALL SEGMENTS ARE LEVEL.
8. INSTALL ALL SOIL NAILS AT 15° DECLINATION ANGLE.

DATUM
(NAVD) 88

0 10 20
SCALE IN FEET

SOIL NAIL SCHEDULE

NO	STA	ELEV.	MIN. BOND LENGTH (FT)	SIZE/GR (KSI)*
1	0+83	220.0	12	#6
2	0+87	220.0	12	#6
3	0+92	220.0	12	#6
4	0+97	220.0	12	#6
5	1+02	220.0	12	#6
6	1+07	220.5	12	#6
7	1+12	220.5	12	#6
8	1+17	220.5	12	#6
9	1+22	220.5	12	#6
10	1+27	220.5	12	#6
11	1+32	220.5	12	#6
12	1+37	222.0	12	#6
13	1+37	218.5	12	#6
14	1+41	220.0	20	#10
15	1+43	218.0	20	#10
16	1+45	220.0	20	#10
17	1+47	218.0	20	#10
18	1+49	220.0	20	#10
19	1+51	218.0	20	#10
20	1+53	220.0	20	#10
21	1+55	218.0	20	#10
22	1+57	220.0	20	#10
23	1+58	217.5	20	#10
24	1+61	220.0	20	#10
25	1+62	217.5	20	#10
26	1+65	220.0	20	#10
27	1+66	217.5	20	#10
28	1+69	220.0	20	#10
29	1+70	217.5	20	#10
30	1+73	220.0	20	#10
31	1+73	217.0	20	#10
32	1+77	220.0	20	#10
33	1+77	217.0	20	#10
34	1+81	220.0	20	#10
35	1+81	217.0	20	#10
36	1+85	220.0	20	#10
37	1+85	217.0	20	#10
38	1+89	220.0	20	#10
39	1+89	217.0	20	#10
40	1+93	220.0	20	#10
41	1+93	216.5	20	#10
42	1+97	220.0	20	#10
43	1+97	216.5	20	#10
44	2+01	220.0	20	#10
45	2+01	216.5	20	#10
46	2+05	220.0	20	#10
47	2+05	216.0	20	#10
48	2+09	220.0	12	#6
49	2+09	216.0	12	#6
50	2+14	219.0	12	#6
51	2+19	218.5	12	#6
52	2+24	218.0	12	#6
53	2+29	218.5	12	#6
54	2+34	218.0	12	#6
55	2+39	217.5	12	#6
56	2+44	216.7	12	#6
57	2+49	215.6	12	#6
TEST 1	1+19.5	220.8	12	#6
TEST 2	1+14	217.0	12	#6
TEST 3	2+19	216.5	12	#6

*ALL GR. 75

WALL 6.50L CURVE DATA

CURVE	P.I. STATION	DELTA	RADIUS	TANGENT	LENGTH	BK. TAN. BEARING
LINEAR	0+00.00			90.99°	18.55'	
CIRCULAR	1+08.65	04°3'36" RT	2545.00'	90.10'	180.13'	86°56'24"
LINEAR	1+98.68			86.94°	36.39'	
CIRCULAR	2+71.42	01°38'24" RT	2547.00'	36.35'	72.69'	85°18'00"
LINEAR	3+07.76			85.30°	92.31'	

FILE NAME	c:\pw_working\wastate\p005088a\dms32767\XL5467_DE_W16-1.dgn			REGION NO. 10	STATE WASH	FED.AID PROJ.NO.
TIME	11:52:06 AM			JOB NUMBER XL5467		
DATE	10/29/2021			CONTRACT NO. C9242		LOCATION NO.
PLOTTED BY	p005088A					
DESIGNED BY	N. ALA					
ENTERED BY						
CHECKED BY	E. KELLEY					
PROJ. ENGR.						
REGIONAL ADM.		REVISION	DATE	BY		

ERIC R. KELLEY
STATE OF WASHINGTON
44060
STRUCTURAL ENGINEER
PROFESSIONAL ENGINEER

P.E. STAMP BOX DATE
P.E. STAMP BOX DATE

Washington State Department of Transportation

FLATIRON LANE

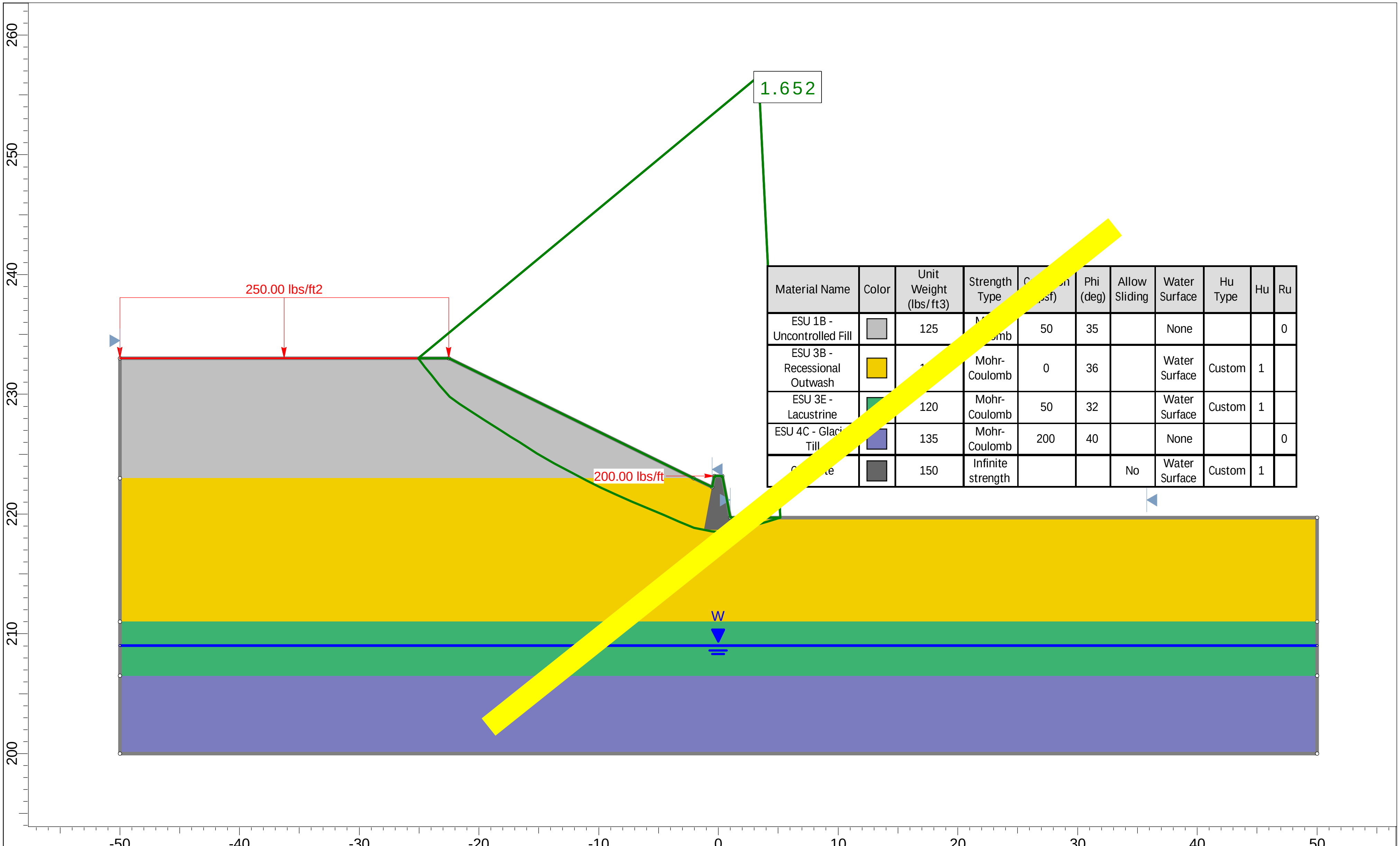
PARSONS

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND PROFILE WALL 6.50L

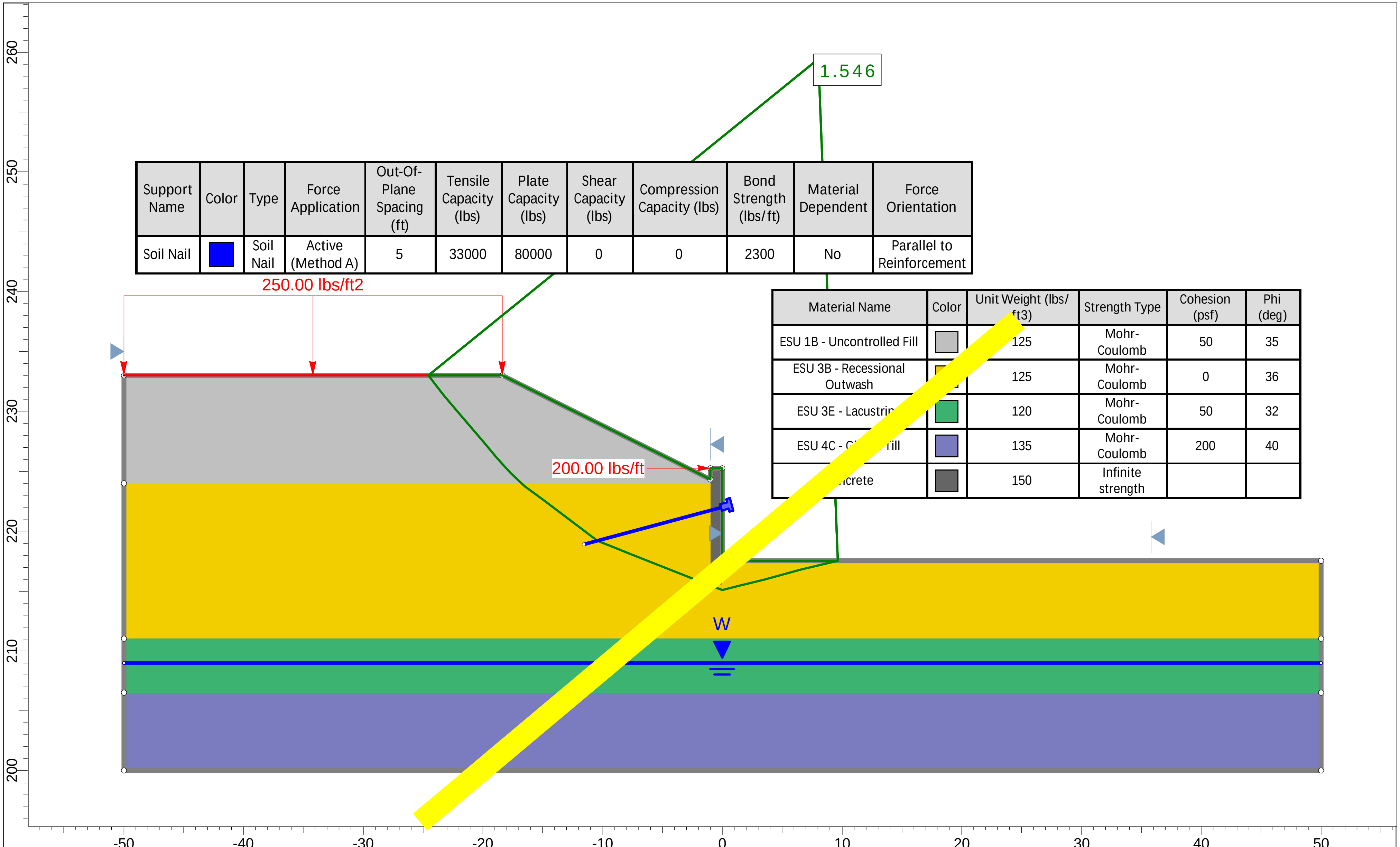
PLAN REF NO W16-1

SHEET OF SHEETS



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	[illegible]	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu	Ru
ESU 1B - Uncontrolled Fill		125	[illegible]	50	35		None			0
ESU 3B - Recessional Outwash		[illegible]	Mohr-Coulomb	0	36		Water Surface	Custom	1	
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32		Water Surface	Custom	1	
ESU 4C - Glaci[illegible] Till		135	Mohr-Coulomb	200	40		None			0
[illegible]		150	Infinite strength			No	Water Surface	Custom	1	

rocscience	*Project* Renton to Bellevue		
	Group Group 1	*Scenario* Static	
	Drawn By	*Company*	
SLIDEINTERPRET 9.012	*Date* 9/6/2021, 12:19:18 PM	*File Name* Wall 6.50L STA 0+82.slmd	



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	5	33000	80000	0	0	2300	No	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrin		120	Mohr-Coulomb	50	32
ESU 4C - Gl Till		135	Mohr-Coulomb	200	40
ncrete		150	Infinite strength		

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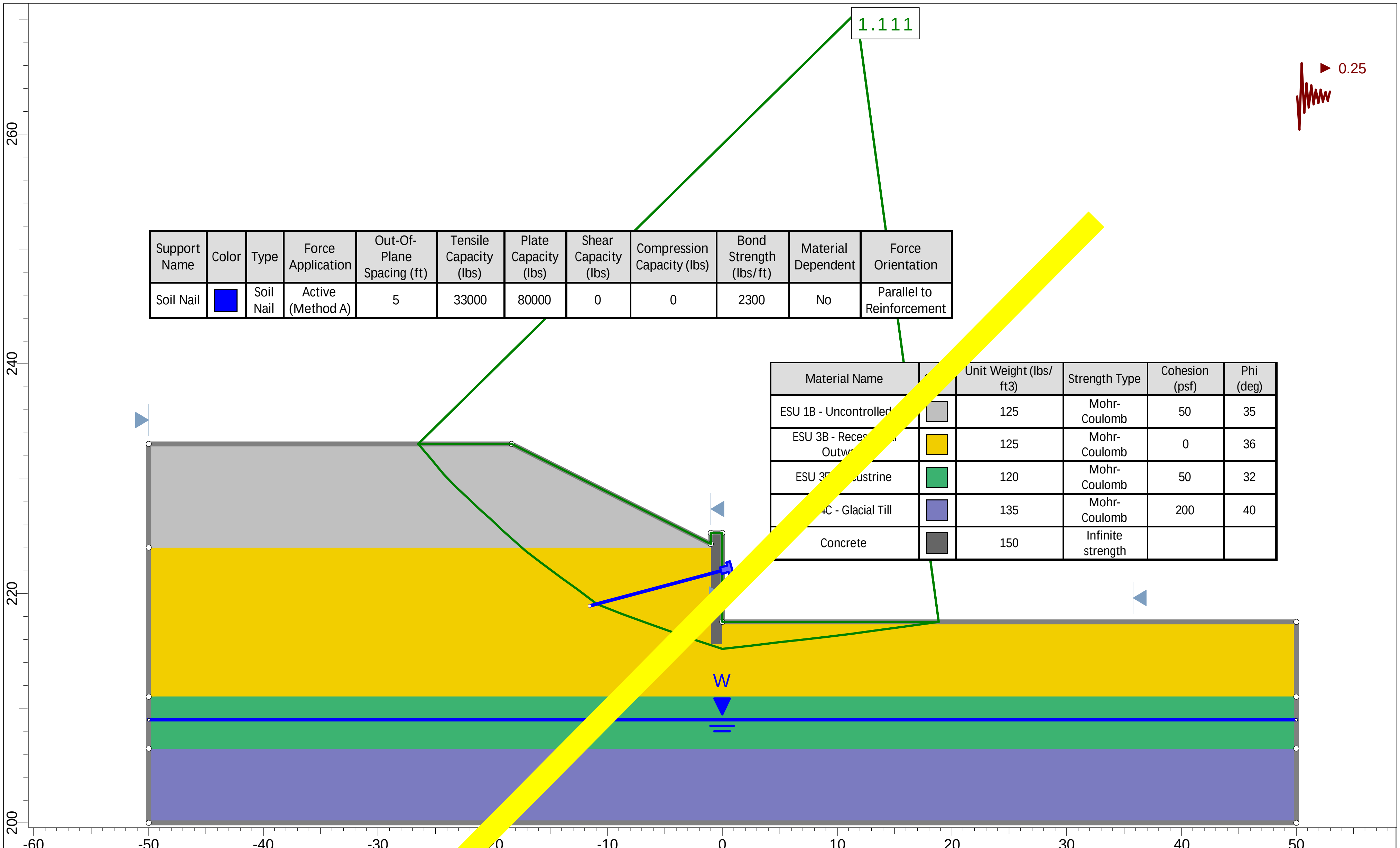
SLIDEINTERPRET 9.012

Project	Renton to Bellevue
Group	Group 1
Scenario	Static
Drawn By	
Company	
Date	9/6/2021, 12:19:18 PM
File Name	Wall 6.50L STA 1+39.5.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	5	33000	80000	0	0	2300	No	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled		125	Mohr-Coulomb	50	35
ESU 3B - Reces[illegible] Outw[illegible]		125	Mohr-Coulomb	0	36
ESU 3[illegible]ustrine		120	Mohr-Coulomb	50	32
[illegible]4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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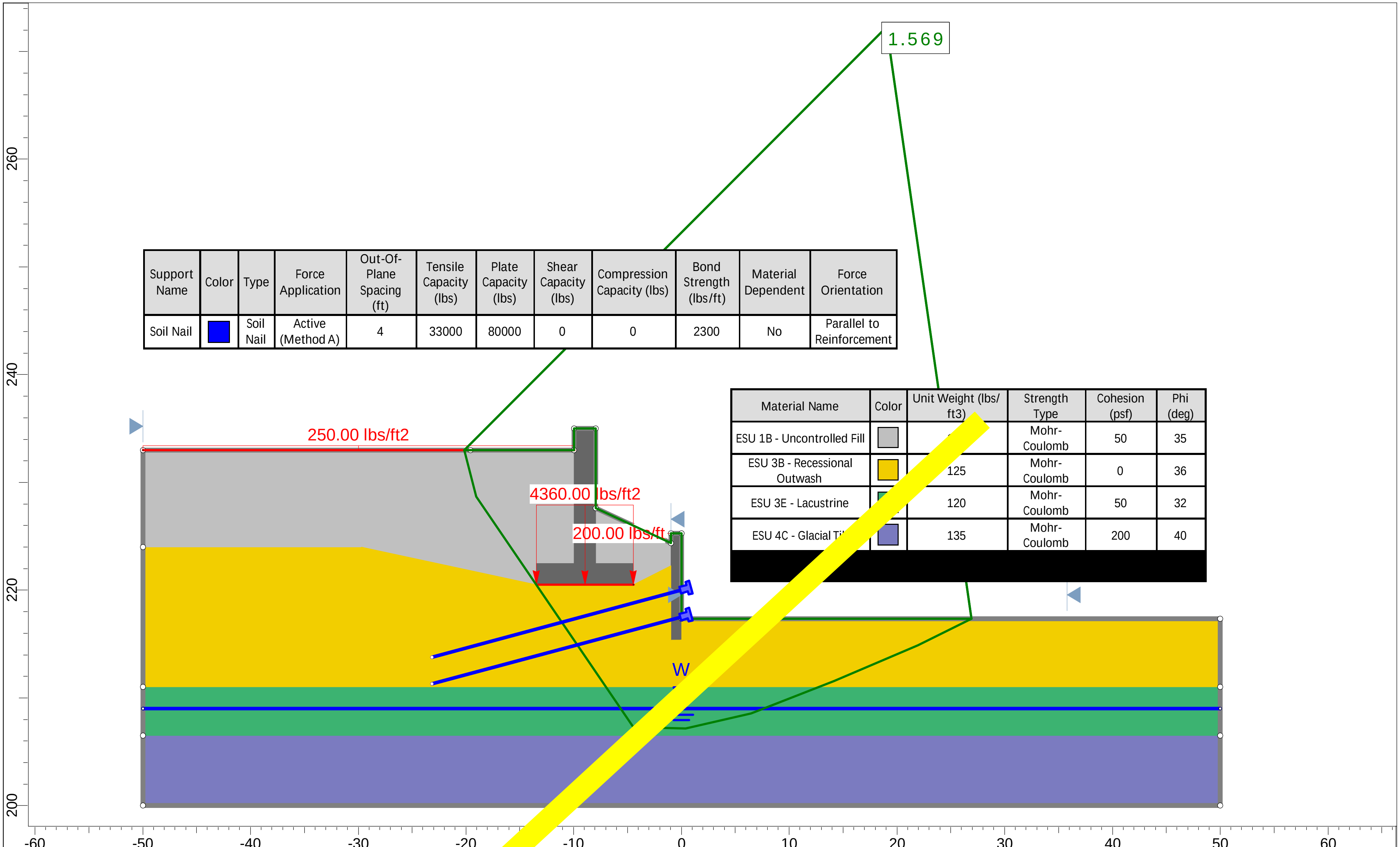
Project	Renton to Bellevue		
Group	Group 1	Scenario	Psuedostatic
Drawn By		Company	
Date	9/6/2021, 12:19:18 PM	File Name	Wall 6.50L STA 1+39.5.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	4	33000	80000	0	0	2300	No	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		[illegible]	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Ti[illegible]		135	Mohr-Coulomb	200	40

[redacted]

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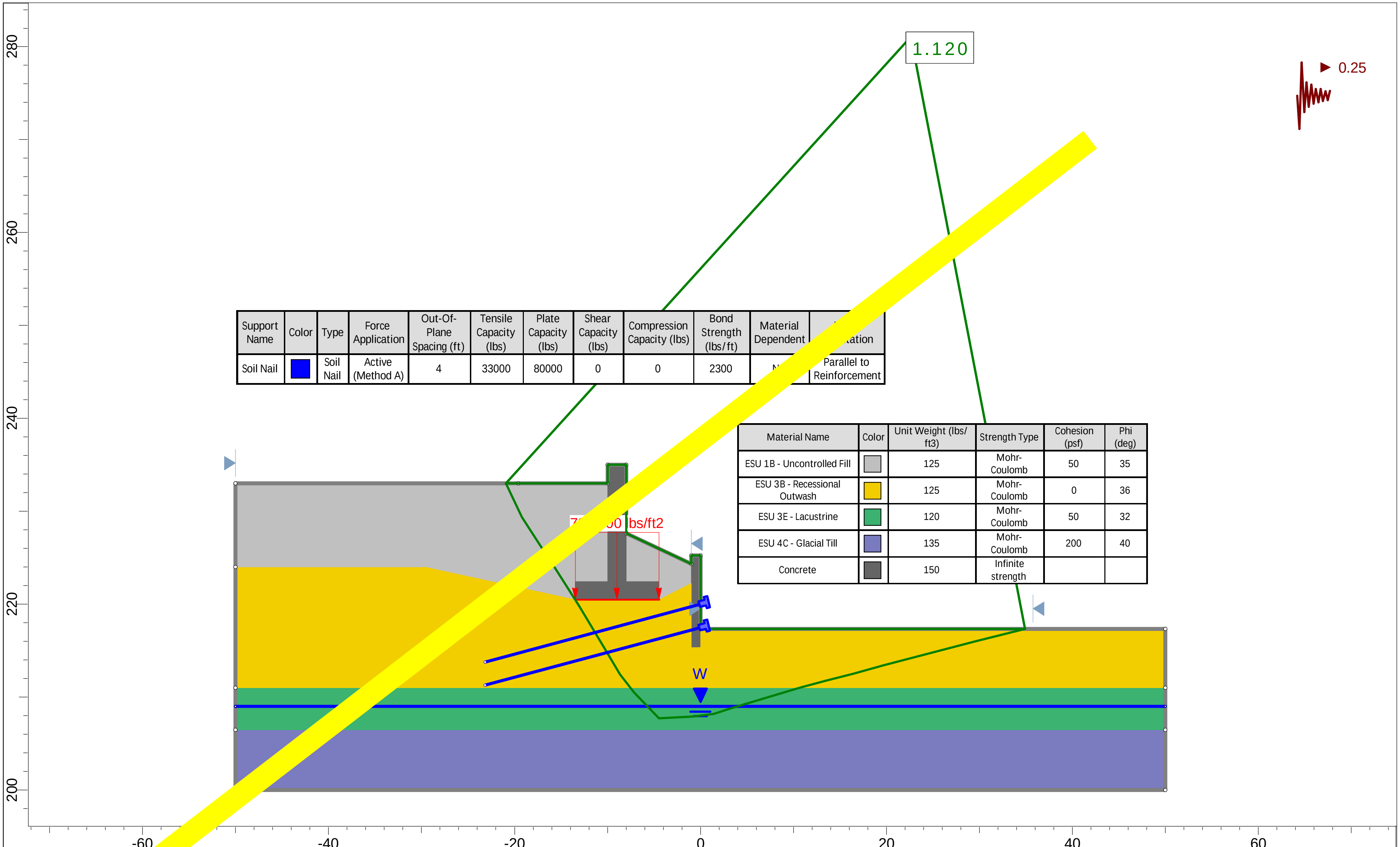
SLIDEINTERPRET 9.012

Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Static
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 1+54.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	[illegible]ation
Soil Nail		Soil Nail	Active (Method A)	4	33000	80000	0	0	2300	N[illegible]	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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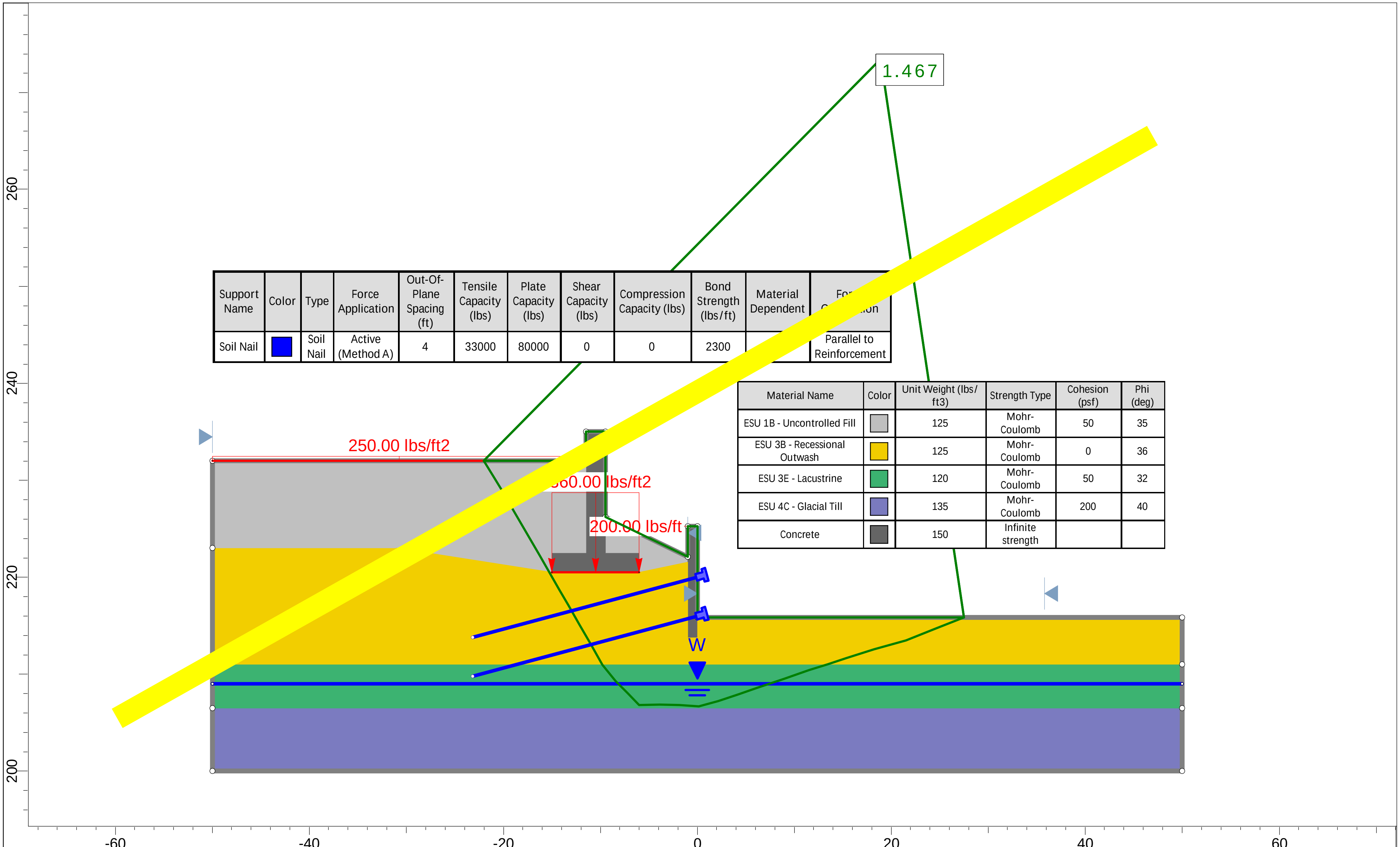
SLIDEINTERPRET 9.012

Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Psuedostatic
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 1+54.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	For [illegible] ion
Soil Nail		Soil Nail	Active (Method A)	4	33000	80000	0	0	2300	[illegible]	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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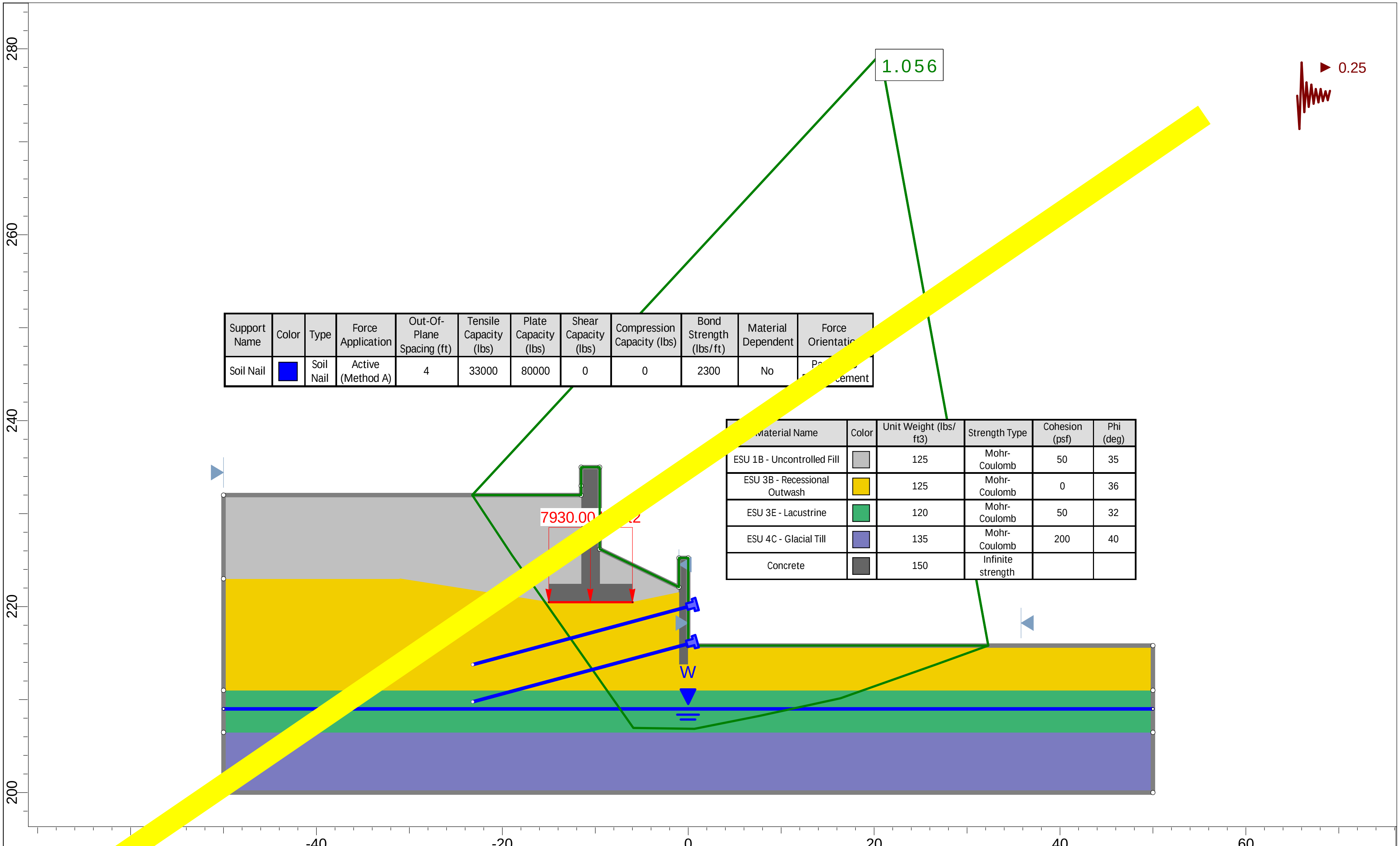
SLIDEINTERPRET 9.012

Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Static
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 2+05.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	4	33000	80000	0	0	2300	No	Pa[illegible]cement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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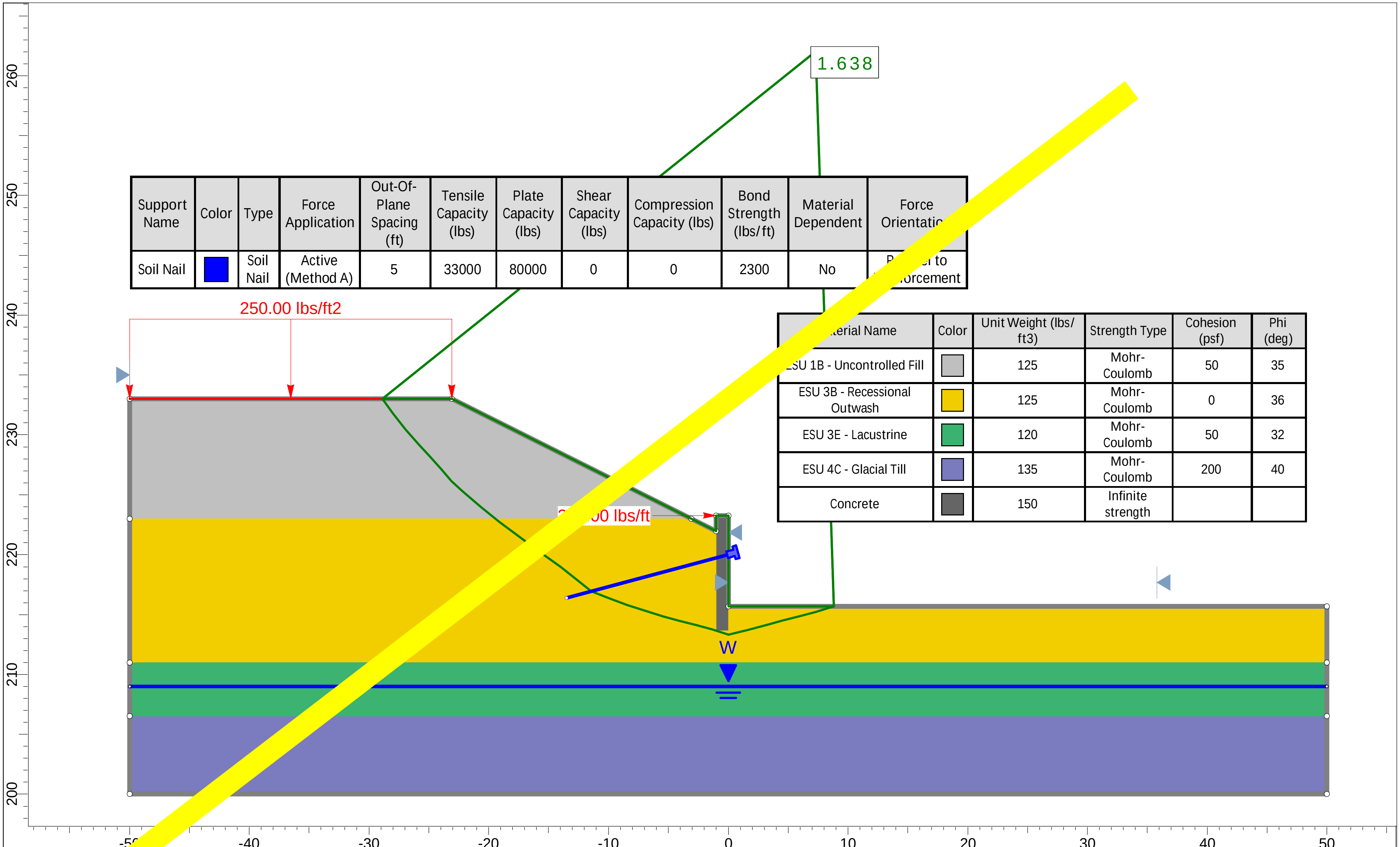
Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Psuedostatic
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 2+05.slmd

SLIDEINTERPRET 9.012



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	5	33000	80000	0	0	2300	No	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ESU 1B - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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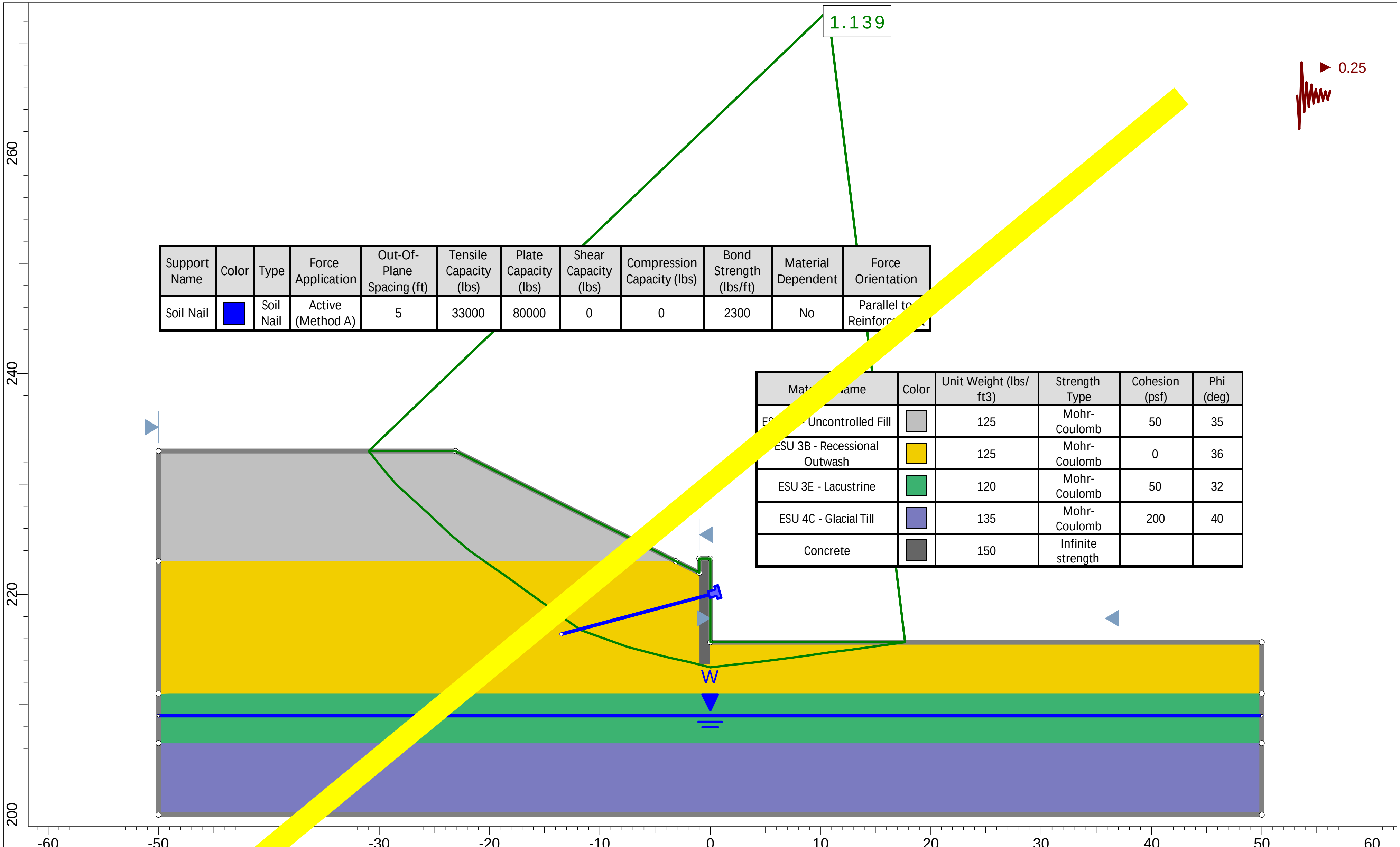
SLIDEINTERPRET 9.012

Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Static
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 2+07.slmd



Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Shear Capacity (lbs)	Compression Capacity (lbs)	Bond Strength (lbs/ft)	Material Dependent	Force Orientation
Soil Nail		Soil Nail	Active (Method A)	5	33000	80000	0	0	2300	No	Parallel to Reinforcement

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
ES[illegible] Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

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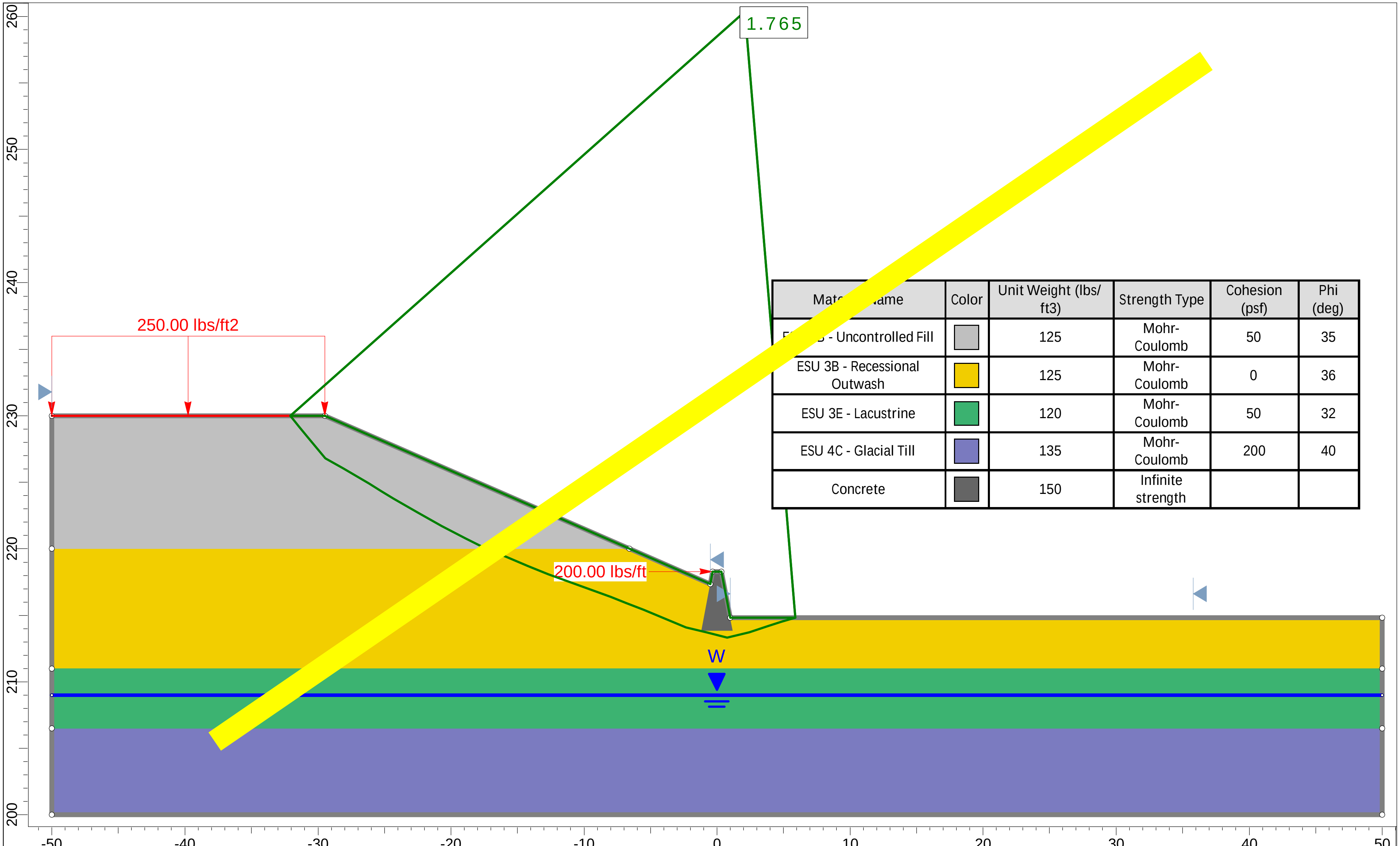
SLIDEINTERPRET 9.012

Project	Renton to Bellevue		
Group	Group 1	*Scenario*	Psuedostatic
Drawn By		*Company*	
Date	9/6/2021, 12:19:18 PM	*File Name*	Wall 6.50L STA 2+07.slmd

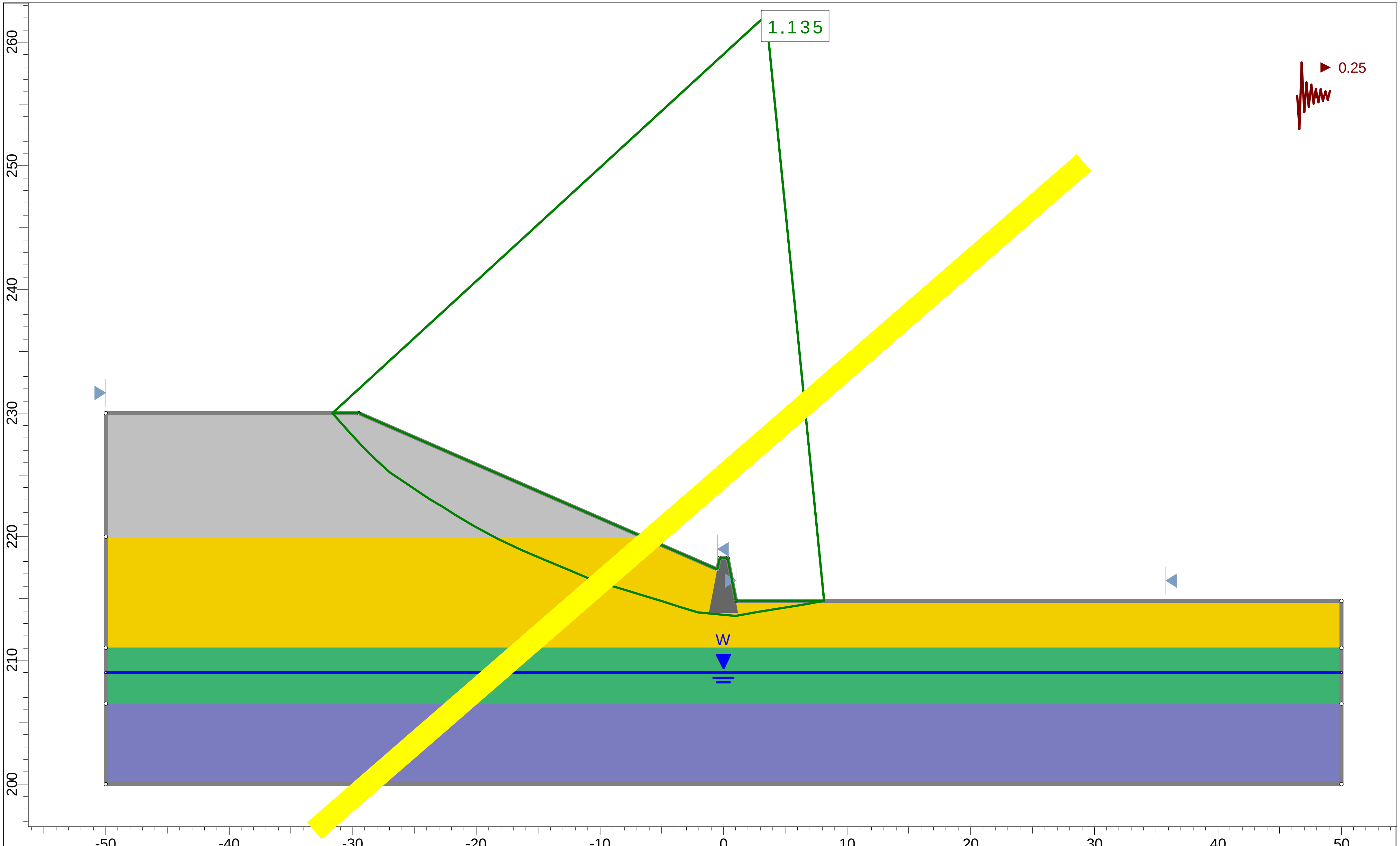


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
[illegible] - Uncontrolled Fill		125	Mohr-Coulomb	50	35
ESU 3B - Recessional Outwash		125	Mohr-Coulomb	0	36
ESU 3E - Lacustrine		120	Mohr-Coulomb	50	32
ESU 4C - Glacial Till		135	Mohr-Coulomb	200	40
Concrete		150	Infinite strength		

Project	Renton to Bellevue		
Group	Group 1	Scenario	Static
Drawn By		Company	
Date	9/6/2021, 12:19:18 PM	File Name	Wall 6.50L STA 2+50.slmd

Terracon

SLIDEINTERPRET 9.012



Terracon	Project	Renton to Bellevue	
	Group: Group 1	Scenario: Psuedostatic	
	Drawn By	Company	
SLIDEINTERPRET 9.012	Date: 9/6/2021, 12:19:18 PM	File Name: Wall 6.50L STA 2+50.slmd	

Check for sliding load from footing on back of wall

$\sigma_{vStrengthImax} := 4.36\ ksf$ $\quad F_{hStrengthImax} := 84\ kip$

$\sigma_{vStrengthImin} := 3.47\ ksf$ $\quad F_{hStrengthImin} := 84\ kip$

$\sigma_{vServiceI} := 3.73\ ksf$ $\quad F_{hServiceI} := 54\ kip$

$\sigma_{vExtremeI} := 7.93\ ksf$ $\quad F_{hExtremeI} := 300\ kip$

$B := 9\ ft$ footing width

$L := 65\ ft$ footing length

$\phi_f := 36\ °$ internal friction angle of drained soil

$V_{StrengthImax} := \sigma_{vStrengthImax} \cdot B \cdot L = 2550.6\ kip$

$V_{StrengthImin} := \sigma_{vStrengthImin} \cdot B \cdot L = 2029.95\ kip$

$V_{ServiceI} := \sigma_{vServiceI} \cdot B \cdot L = 2182.05\ kip$

$V_{ExtremeI} := \sigma_{vExtremeI} \cdot B \cdot L = 4639.05\ kip$

Total vertical forces

$C := 1.0$ AASHTO EQ 10.6.3.4-2

$R_{\tau StrengthI} := C \cdot V_{StrengthImax} \cdot \tan(\phi_f) = 1853.12\ kip$ Nominal sliding resistance - Strength I

$R_{\tau ExtremeI} := C \cdot V_{ExtremeI} \cdot \tan(\phi_f) = 3370.47\ kip$ Nominal sliding resistance - Extreme I

$\varphi_\tau := 0.8$ $\quad \varphi_{ep} := 0.5$ AASHTO Table 10.5.5.2.2-1

$R_{ep} := 0\ kip$ Per AASHTO 11.6.3.5, passive soil pressure shall be neglected

$R_{RStrengthI} := \varphi_\tau \cdot R_{\tau StrengthI} + \varphi_{ep} \cdot R_{ep} = 1482.5\ kip$

$R_{RExtremeI} := \varphi_\tau \cdot R_{\tau ExtremeI} + \varphi_{ep} \cdot R_{ep} = 2696.37\ kip$

Sliding Resistance

$R_{RStrengthI} > F_{hStrengthImax}$ and $R_{RExtremeI} > F_{hExtremeI}$

No passive wedge on the soil nail wall

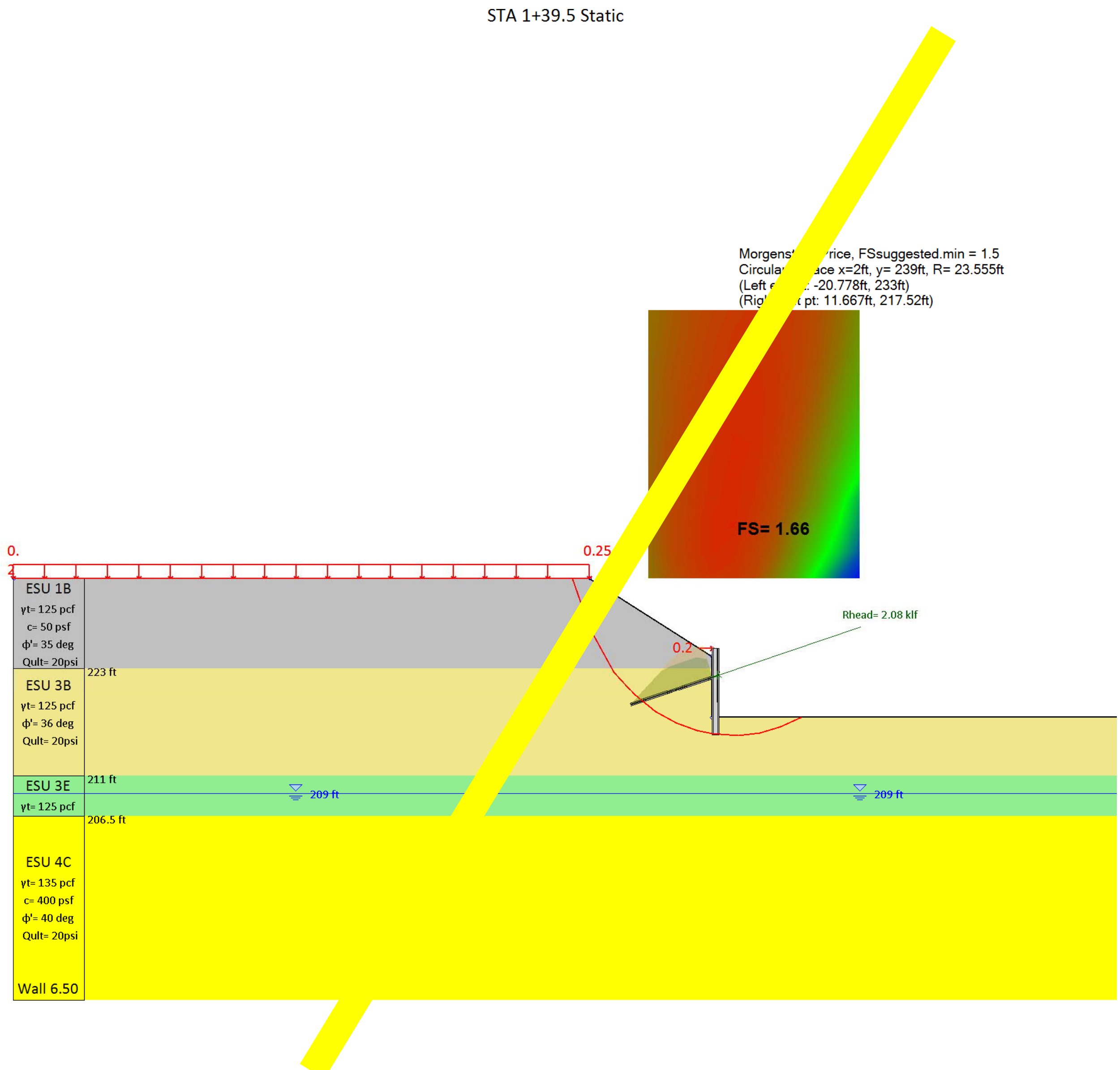
SnailPlus 2021: Report Output

Project: Renton To Bellevue

Company: Terracon
Prepared by engineer: YY
File number: 1
Time: 10/29/2021 10:5[illegible]:26 AM

File: N:\Projects\2021\81215044\Working Files\Calculations-Analyses\Wall 6.50L\6. Soil Nail\Snail Plus\Wall 6.50 - 1 row.SNLP

Quick analysis summary for design section: STA 1+39.5 Static



Stage	Calculation	FS	Fmax.Nails	Fmax.Nails	Fmax.Mob	STR Check	STR Check	STR Chec	Max.	Min.
Section	Status	Slope	(k)	Head (k)	(k)	Nails	Plates	Facing	Reinf.	Reinf.
Stage 0	Calculated	1.66	13.09	10.41	10.49	0.714	0.167	0.066	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing (To).
Fmax.Mob = Maximum mob axial nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.66	1.5	Circle	2	239	23.555	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall [illegible]s(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	18.33	0.714	N/A	[illegible]A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on a[illegible]ils
Nail stability	External-Int[illegible]l
Nail shear	Ignor[illegible]
FS on nail STR strength	1[illegible]
FS on nail pullout	[illegible]
FS on facing bending	1.5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Table: Nails & max mobilized head forces

Name	Nail	α	x	[illegible]l.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	1: N1 - #6	15	-1	222	12	0	5	2.0816	10.41

Fhead= Mobilized force at nail head (facing), deter[illegible]ed from pressures at facing.

Table: Surface point coordinates for last [illegible]age

Point	x (ft)	El. (ft)
1	-100	233
2	-18.38	233
3	-1	224.31
4	-1	217.52
5	60	217.52

Soil type property d[illegible]a

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	1	0.36

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 1+39.5 Static

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion [illegible] limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

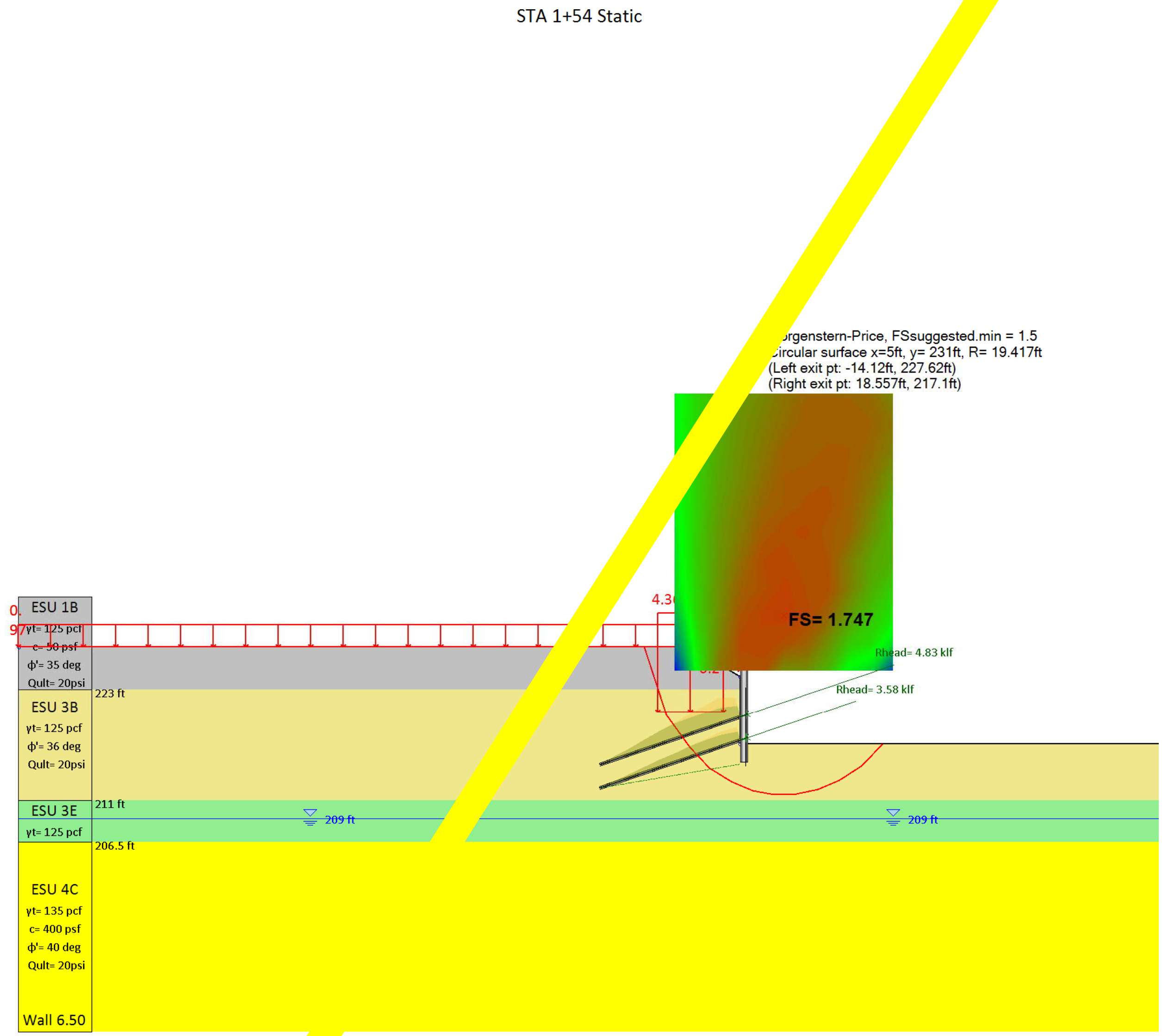
Soil nail input data for design section STA 1+39.5 Static

Name	Nail	α	x	El.	Lfix	Lfr[illegible]	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	[illegible]	(ft)	(in^2)	(in)	(ksi)
Nail 1	1: N1 - #6	15	-1	222	12	[illegible]0	5	0.44	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D ope[illegible]	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(i[illegible]	Studs	c studs	Bars
Nail 1	222	12	2	50	[illegible]	N/A	N/A	#6

Quick analysis summary for design section: STA 1+54 Static



Stage Section	Calculation Status	FS Slope	Fmax.Nails (k)	Fmax.Nails Head (k)	Fmax.Mob (k)	STR Check Nails	STR Check Plates	STR Chec Facing	Max. Reinf.	Min. Reinf.
Stage 0	Calculated	1.747	30.27	25.03	30.27	0.669	0.407	0.13	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing (To).
Fmax.Mob = Maximum mob axial nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.747	1.5	Circle	5	231	19.417	N[illegible]	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	V[illegible] Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	45.2	0.669	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on al[illegible]ils
Nail stability	External-Inte[illegible]
Nail shear	Ignore[illegible]
FS on nail STR strength	1.[illegible]
FS on nail pullout	[illegible]
FS on facing bending	[illegible]5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Table: Nails & max mobilized head forces

Name	Nail	α	x	[illegible]	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	[illegible]	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	3: N1 - #10	15	-1	[illegible]20	20	0	4	4.8324	19.33
Nail 1	3: N1 - #10	15	-1	[illegible]217.5	20	0	7	3.5751	25.03

Fhead= Mobilized force at nail head (facing), determi[illegible] from pressures at facing.

Table: Surface point coordinates for last st[illegible]e

Point	x (ft)	[illegible] (ft)
1	-100	[illegible]27.62
2	-7.96	227.62
3	-1	224.36
4	-1	217.1
5	60	217.1

Soil type property data

Name	γtot	[illegible]	Φ'	c'	Su	qBond	Color
	(pcf)	[illegible]cf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	1	0.[illegible]

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 1+54 Static

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 1+54 Static

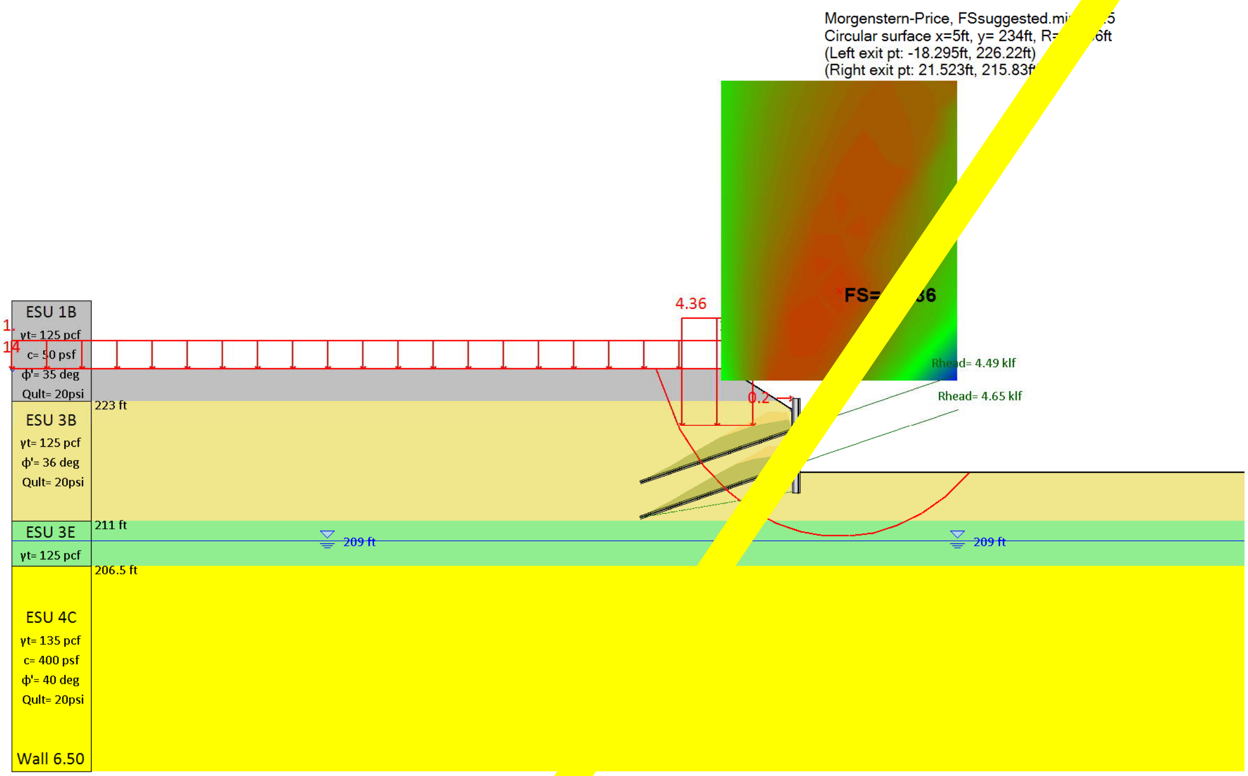
Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	[illegible]	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	3: N1 - #1	15	-1	220	20	0	4	1.27	6	75
Nail 1	3: N1 - #1	15	-1	217.5	20	0	7	1.27	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
Nail 1	220	12	2	50	1	N/A	N/A	#6
Nail 1	217.5	12	[illegible]	50	1	N/A	N/A	#6

Quick analysis summary for design section: STA 2+05 Static

STA 2+05 Static



Stage Section	Calculation Status	FS Slope	Fmax.Nails (k)	max.Nails Head (k)	Fmax.Mob (k)	STR Check Nails	STR Check Plates	STR Chec Facing	Max. Reinf.	Min. Reinf.
Stage 0	Calculated	1.686	28.9	18.61	28.9	0.639	0.388	0.127	Yes	Yes

Fmax Nails = Maximum axial nail force in analys
Fmax Nail@head = Maximum axial nail force cing (To).
Fmax.Mob = Maximum mob axial nail force f To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress check for nails, Design /Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates ching and bending).
STR Facing= Stress check for facing, D gn load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Acti[illegible]deg)	Passive (deg)
Stage 0	Yes	1.686	1.5	Circle	5	234	24.56	[illegible]A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	[illegible]ll Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	45.21	0.639	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	[illegible]x	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	[illegible]ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	3: N1 - #10	15	-1	220	20	0	4	4.4851	17.94
Nail 1	3: N1 - #10	15	-1	216.5	20	0	4	4.6516	18.61

Fhead= Mobilized force at nail head (facing), determined from pres[illegible]es at facing.

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-100	226.22
2	-9.08	226.22
3	-1	222.1
4	-1	215.83
5	60	215.83

Soil type property data

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg[illegible]	(psf)	(psf)	(psi)	
ESU 1B	125	125	3[illegible]	50	N/A	20	
ESU 3B	125	125	[illegible]	0	N/A	20	
ESU 3E	125	125	[illegible]2	50	N/A	20	
ESU 4C	135	135	[illegible]40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	1	0.36

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 2+05 Static

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

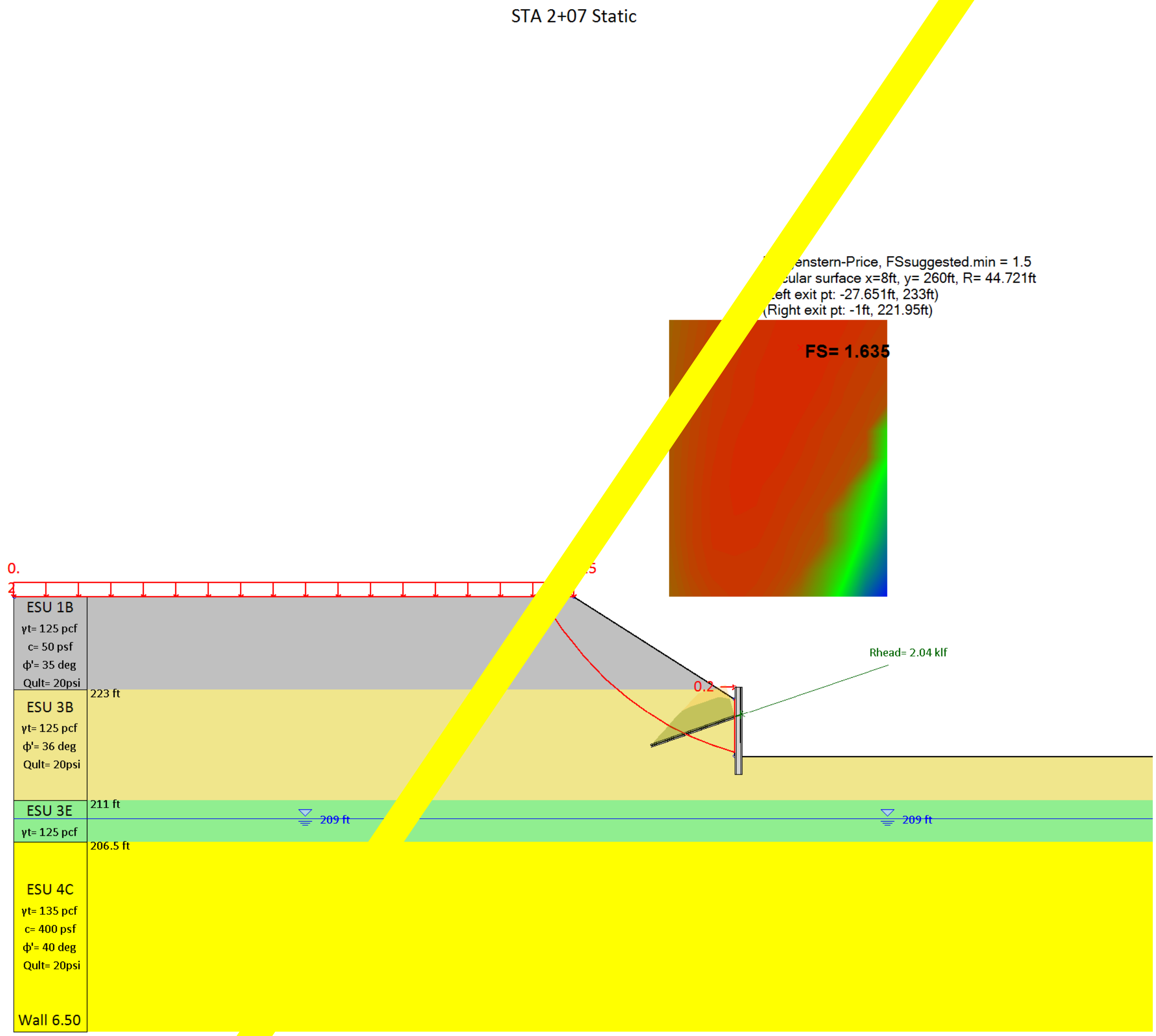
Soil nail input data for design section STA 2+05 Static

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	3: N1 - #1	15	-1	220	20	0	4	1.27	6	75
Nail 1	3: N1 - #1	15	-1	216.5	20	0	4	1.27	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
Nail 1	220	12	2	50	1	N/A	N/A	#6
Nail 1	216.5	12	2	50	1	N/A	N/A	#6

Quick analysis summary for design section: STA 2+07 Static



Stage	Calculation	FS	Fmax.Nails	Fmax.Nails	Fmax.Mob	STR Check	STR Check	STR Chec	Max.	Min.
Section	Status	Slope	(k)	Head (k)	(k)	Nails	Plates	Facing	Reinf.	Reinf.
Stage 0	Calculated	1.635	12.84	10.22	10.45	0.701	0.167	0.063	Yes	Yes

Fmax Nails= Maximum axial nail force in analysis.
Fmax Nails Head = Maximum axial nail force at facing (To).
Fmax.Mob = Maximum mob axial nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails = Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.635	1.5	Circle	8	260	44.721	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support[illegible]e	Wall Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	18.33	0.701	N[illegible]	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Permanent structure long term
Min required FS	1.5
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settin[illegible]on all nails
Nail stability	Exter[illegible]nternal
Nail shear	[illegible]nored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.5
FS on facing punching	1.5
FS on bolts	1.7
FS on bearing	3

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	1: N1 - #6	15	-1	220	12	0	5	2.0444	10.22

Fhead= Mobilized force at nail head (facing), de[illegible]nined from pressures at facing.

Table: Surface point coordinates for l[illegible] stage

Point	x (ft)	El. (ft)
1	-100	233
2	-23.1	233
3	-1	221.95
4	-1	215.78
5	60[illegible]	215.65

Soil type property [illegible]a

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	12[illegible]	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	[illegible]
206.5	ESU 4C	1	[illegible]

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS: ALL STAGES

Soil nail results for design section: STA 2+07 Static

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 2+07 Static

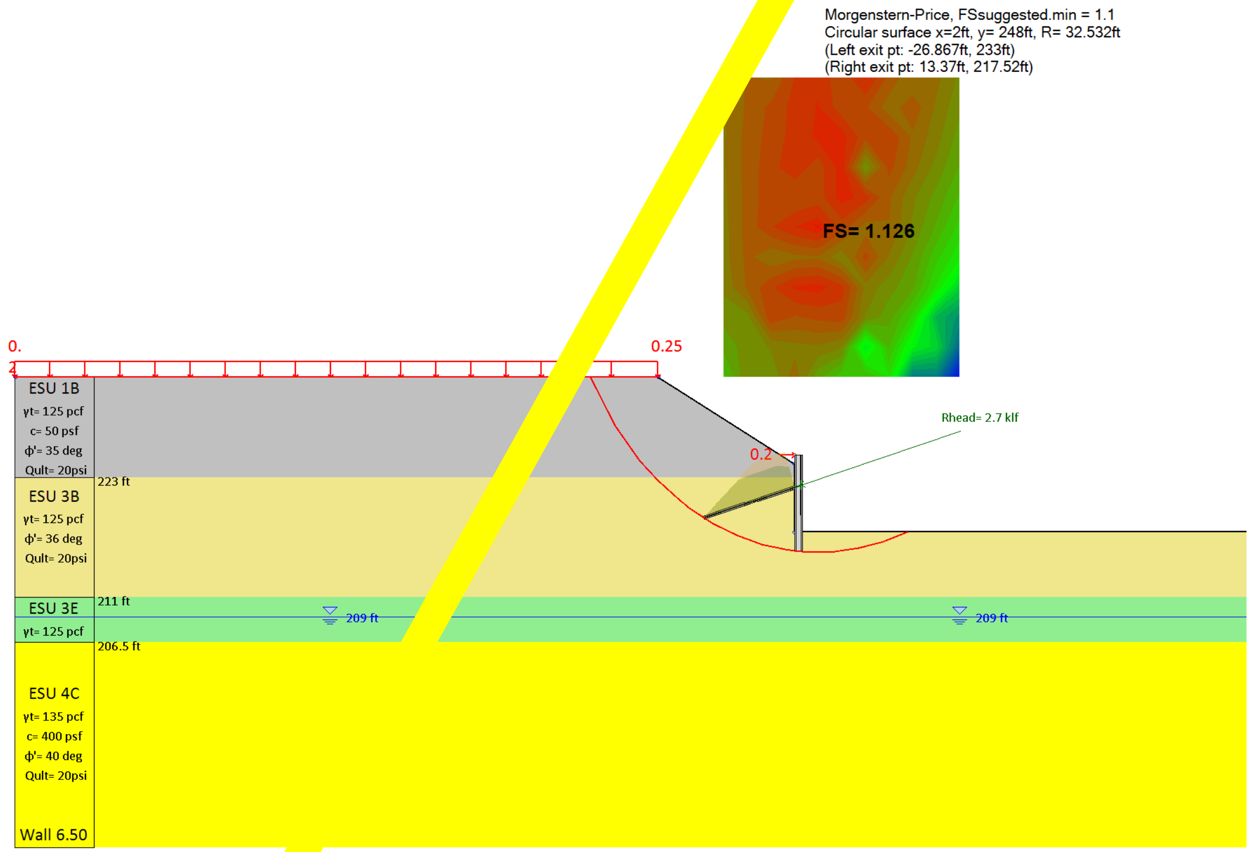
Name	Nail	α	x	El.	L	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	1: N1 - #6	15	-1	220	12	0	5	0.44	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(k[illegible]	(in)	Studs	c studs	Bars
Nail 1	220	12	2	[illegible]	1	N/A	N/A	#6

Quick analysis summary for design section: STA 1+39.5 Seismic

STA 1+39.5 Seismic



Stage	Calculati[illegible]	FS	Fmax.Nails	Fmax.Nails	Fmax.Mob	STR Check	STR Check	STR Chec	Max.	Min.
Section	Stat[illegible]	Slope	(k)	Head (k)	(k)	Nails	Plates	Facing	Reinf.	Reinf.
Stage 0	Calc[illegible]ed	1.126	17	13.51	13.61	0.695	0.163	0.077	Yes	Yes

Fmax Nails = Maxi[illegible]n axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing (To).
Fmax.Mob = Maximum mob axial nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Stage 0	Yes	1.126	1.1	Circle	2	248	32.532	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	M[illegible]eismic(
N/A	N/A	N/A		Service Facto	24.44	0.695	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.1
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.25g, az= 0g
Seismic pressures	Mononobe-Okabe
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on [illegible]ails
Nail stability	External-In[illegible]al
Nail shear	Ign[illegible]d
FS on nail STR strength	[illegible]5
FS on nail pullout	1.5
FS on facing bending	1.1
FS on facing punching	1.1
FS on bolts	1.3
FS on bearing	2.3

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	1: N1 - #6	15	[illegible]	222	12	0	5	2.7026	13.51

Fhead= Mobilized force at nail head (facing) [illegible]termined from pressures at facing.

Table: Surface point coordinates f[illegible] last stage

Point	x (ft)	El. (ft)
1	-100	233
2	-18[illegible]	233
3	[illegible]	224.31
4	[illegible]1	217.52
5	60	217.52

Soil type property data

Name	γtot	γdry	Φ'	c'	Su	qB[illegible]	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	[illegible])	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained cond[illegible]n)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0[illegible]
223	ESU 3B	1	[illegible]1
211	ESU 3E	1	[illegible].47
206.5	ESU 4C	1	0.36

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 1+39.5 Seismic

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 1+39.5 Seismic

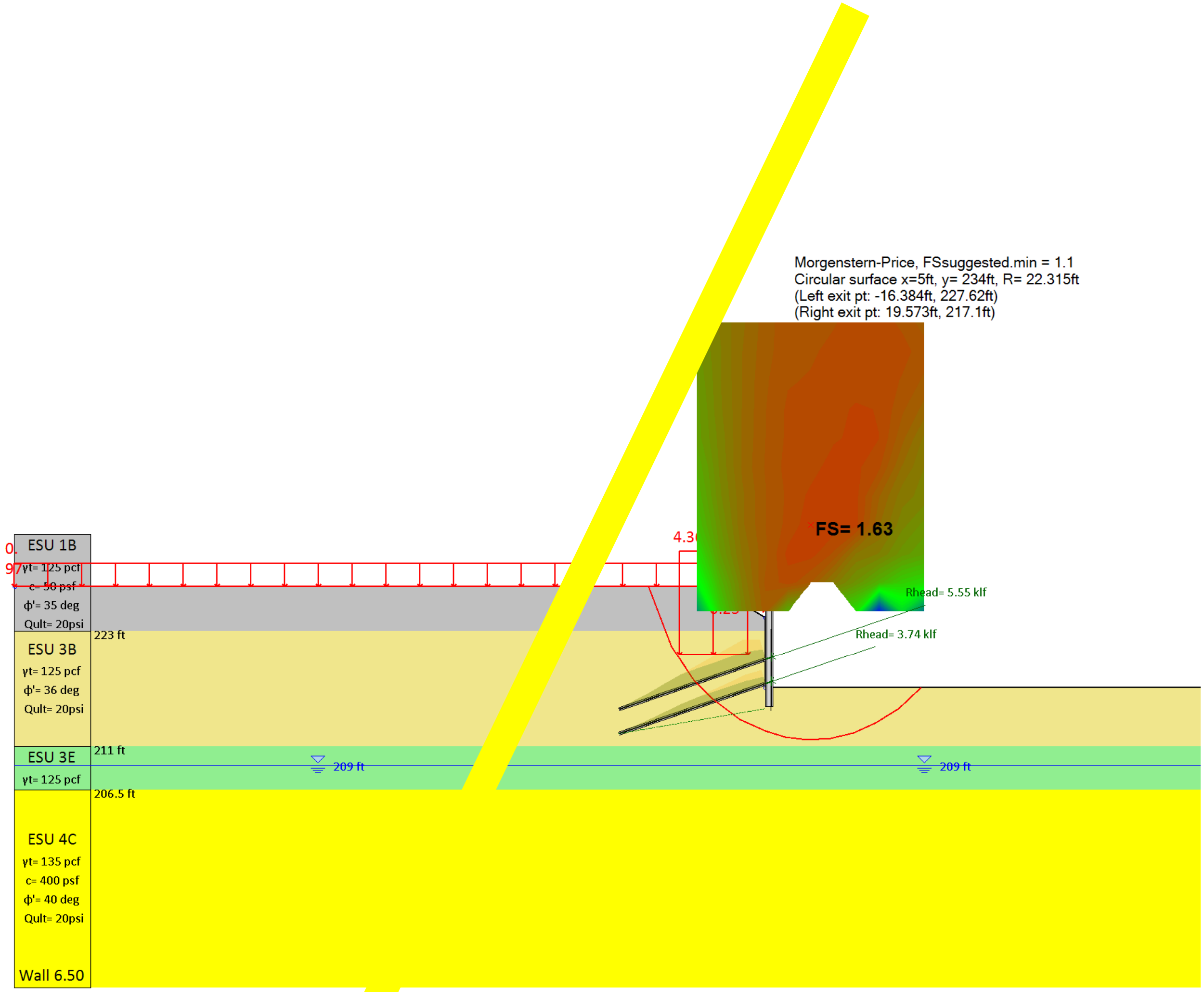
Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	1: N1 - #6	15	-1	222	12	[illegible]	5	0.44	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D ope[illegible]	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(i[illegible]	Studs	c studs	Bars
Nail 1	222	12	2	50	[illegible]1	N/A	N/A	#6

Quick analysis summary for design section: STA 1+54 Seismic

STA 1+54 Seismic



Stage Section	Calculation Status	FS Slope	Fmax.Nails (k)	Fmax.Nails Head (k)	Fmax.Mob (k)	STR Check Nails	STR Check Plates	STR Chec Facing	Max. Reinf.	Min. Reinf.
Stage 0	Calculated	1.6[illegible]	31.69	26.2	31.69	0.525	0.402	0.143	Yes	Yes

Fmax Nails = Maximum axial na[illegible]rce in analysis.
Fmax Nail@head = Maximum [illegible] nail force at facing (To).
Fmax.Mob = Maximum mob a[illegible] nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress check fo[illegible]s, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check [illegible]ail plates (punching and bending).
STR Facing= Stress chec[illegible] facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Ac[illegible] (deg)	Passive (deg)
Stage 0	Yes	1.63	1.1	Circle	5	234	22.315	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Suppor[illegible]e	Wall Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	60.27	0.525	[illegible]	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.1
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.25g, az= 0[illegible]
Seismic pressures	Mononobe-Ok[illegible]
Surface search	Circul[illegible]
Min. slice width	[illegible]
Tolerance	[illegible]%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.35
FS on nail pullout	1.5
FS on facing bending	1.1
FS on facing punching	1.1
FS on bolts	1.3
FS on bearing	2.3

Table: Nails & max mob[illegible]ed head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Secti[illegible]	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	3: N[illegible]10	15	-1	220	20	0	4	5.5493	22.2
Nail 1	3:[illegible] - #10	15	-1	217.5	20	0	7	3.7425	26.2

Fhead= Mobilized force at nail head (facing), determined from pressures at facing.

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-100	227.62
2	-7.96	227.62
3	-1	224.36
4	-1	217.1
5	60	217.1

Soil type property data

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	[illegible]	
ESU 3E	125	125	32	50	N/A	[illegible]	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	1	[illegible]

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 1+54 Seismic

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 1+54 Seismic

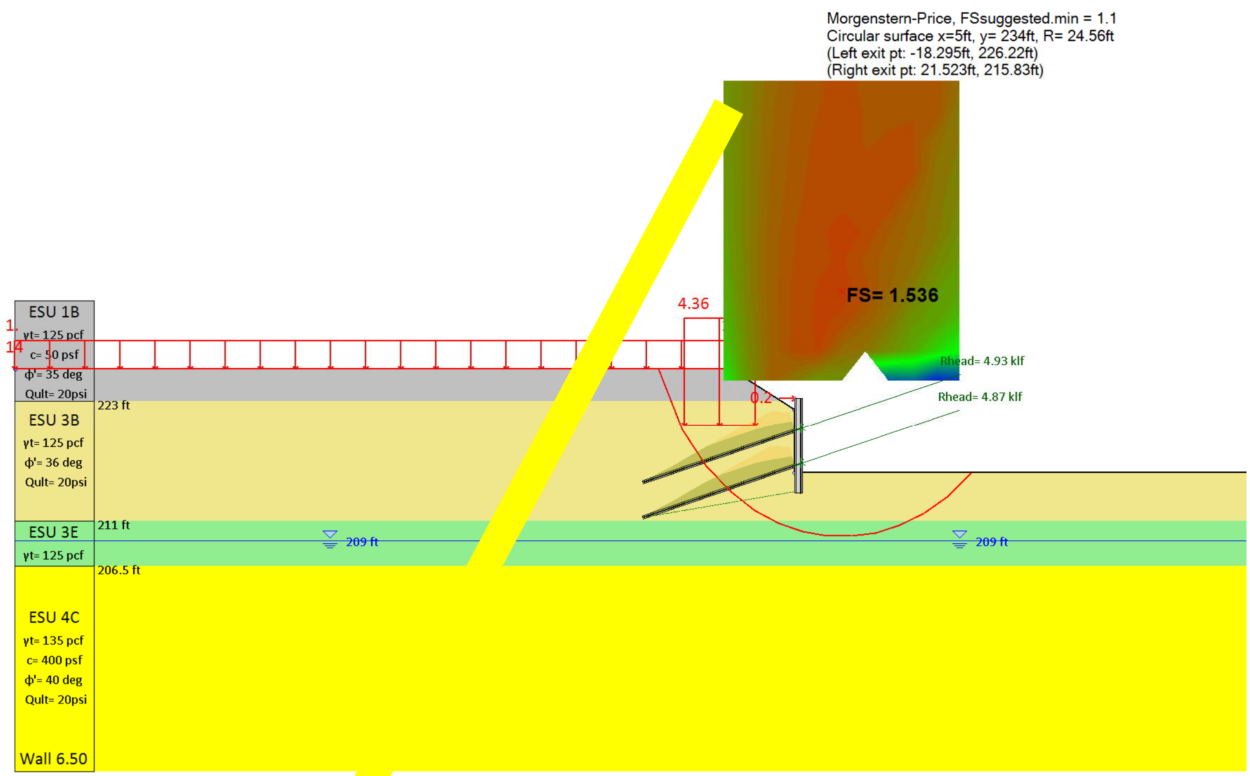
Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	[illegible]	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	3: N1 - #1	15	-1	220	20	0	4	1.27	6	75
Nail 1	3: N1 - #1	15	-1	217.5	20	0	7	1.27	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
Nail 1	220	12	2	50	1	N/A	N/A	#6
Nail 1	217.5	12	[illegible]	50	1	N/A	N/A	#6

Quick analysis summary for design section: STA 2+05 Seismic

STA 2+05 Seismic



Stage Section	Calculation Status	F[illegible] S[illegible]	Fmax.Nails (k)	Fmax.Nails Head (k)	Fmax.Mob (k)	STR Check Nails	STR Check Plates	STR Chec Facing	Max. Reinf.	Min. Reinf.
Stage 0	Calculated	[illegible]6	30.26	19.71	30.61	0.502	0.387	0.134	Yes	Yes

Fmax Nails = Maximum axi[illegible]il force in analysis.
Fmax Nail@head = Maxim[illegible] axial nail force at facing (To).
Fmax.Mob = Maximum m[illegible] axial nail force from To/Tmax ratio Clouterre (Tmax)
STR Nails= Stress chec[illegible]r nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress ch[illegible] for nail plates (punching and bending).
STR Facing= Stress [illegible]ck for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	[illegible]ive (deg)	Passive (deg)
Stage 0	Yes	1.536	1.1	Circle	5	234	24.56	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Supr[illegible]Mre	Wall Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	60.28	0.502	[illegible]/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.1
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.25g, az= 0[illegible]
Seismic pressures	Mononobe-O[illegible]
Surface search	Circul[illegible]
Min. slice width	3[illegible]
Tolerance	[illegible]
Force Tolerance	[illegible]10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.35
FS on nail pullout	1.5
FS on facing bending	1.1
FS on facing punching	1.1
FS on bolts	1.3
FS on bearing	2.3

Table: Nails & max mobiliz[illegible]ead forces

Name	Nail	[illegible]α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	3: N1 - #1[illegible]	15	-1	220	20	0	4	4.9265	19.71
Nail 1	3: N1 - [illegible]	15	-1	216.5	20	0	4	4.8709	19.48

Fhead= Mobilized f[illegible]e at nail head (facing), determined from pressures at facing.

Table: Surface[illegible]oint coordinates for last stage

Point	x (ft)	El. (ft)
1	-100	226.22
2	-9.08	226.22
3	-1	222.1
4	-1	215.83
5	60	215.83

Soil type property data

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	K
233	ESU 1B	1	[illegible]43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	[illegible]	0.36

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 2+05 Seismic

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 2+05 Seismic

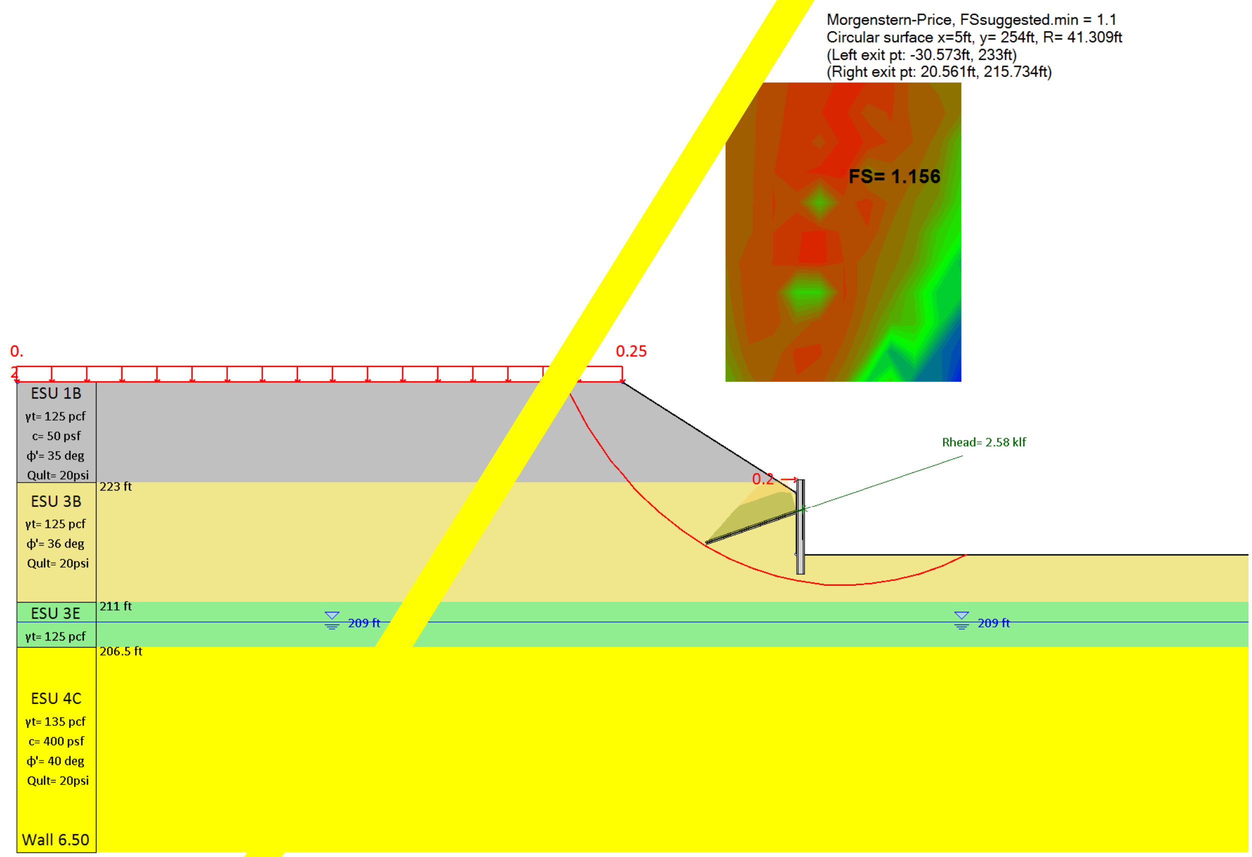
Name	Nail	α	x	El.	Lfix	Lfr[illegible]	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	[illegible]	(ft)	(in^2)	(in)	(ksi)
Nail 1	3: N1 - #1	15	-1	220	20	[illegible]	4	1.27	6	75
Nail 1	3: N1 - #1	15	-1	216.5	20	0	4	1.27	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D ope[illegible]	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(i[illegible]	Studs	c studs	Bars
Nail 1	220	12	2	50	[illegible]	N/A	N/A	#6
Nail 1	216.5	12	2	50	[illegible]	N/A	N/A	#6

Quick analysis summary for design section: STA 2+07 Seismic

STA 2+07 Seismic



Stage Section	C[illegible]ation [illegible]tatus	FS Slope	Fmax.Nails (k)	Fmax.Nails Head (k)	Fmax.Mob (k)	STR Check Nails	STR Check Plates	STR Chec Facing	Max. Reinf.	Min. Reinf.
Stage 0	[illegible]alculated	1.156	16.23	12.91	13.2	0.664	0.163	0.074	Yes	Yes

Fmax Nails[illegible]aximum axial nail force in analysis.
Fmax Nai[illegible]ead = Maximum axial nail force at facing (To).
Fmax.M[illegible] Maximum mob axial nail force from To/Tmax ratio Clouterre (Tmax)
STR N[illegible]= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR [illegible]es= Stress check for nail plates (punching and bending).
ST[illegible]cing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (d[illegible]	Passive (deg)
Stage 0	Yes	1.156	1.1	Circle	5	254	41.309	N/[illegible]	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	V[illegible] Mres(k-	MEQ seismic(
N/A	N/A	N/A		Service Facto	24.44	0.664	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Extreme event, flood or seismic
Min required FS	1.1
Method	Morgenstern-Price
Nail methods	Available shear
Earthquake	ax= 0.25g, az= 0g
Seismic pressures	Mononobe-Okabe
Surface search	Circular
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	[illegible]
MP initial Lamda.0	[illegible]0
Soil nail analysis	Same [illegible]ings on all nails
Nail stability	[illegible]ernal-Internal
Nail shear	Ignored
FS on nail STR strength	1.35
FS on nail pullout	1.5
FS on facing bending	1.1
FS on facing punching	1.1
FS on bolts	1.3
FS on bearing	2.3

Table: Nails & max mobilized head for[illegible]s

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
Nail 1	1: N1 - #6	15	-1	220	12	0	5	2.5829	12.91

Fhead= Mobilized force at nail head[illegible]cing), determined from pressures at facing.

Table: Surface point coordi[illegible]es for last stage

Point	[illegible]	El. (ft)
1	[illegible]00	233
2	-23.1	233
3	-1	221.95
4	-1	215.78
5	60	215.65

Soil type property data

Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1B	125	125	35	50	N/A	20	
ESU 3B	125	125	36	0	N/A	20	
ESU 3E	125	125	32	50	N/A	20	
ESU 4C	135	135	40	400	N/A	20	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: Wall 6.50, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
233	ESU 1B	1	0.43
223	ESU 3B	1	0.41
211	ESU 3E	1	0.47
206.5	ESU 4C	[illegible]	0.36

SLOPE STABILITY ANALYSIS: SOIL NAIL RESULTS ALL STAGES

Soil nail results for design section: STA 2+07 Seismic

GENERAL SOIL NAIL DATA

Soil nails are concidered only when a slope stability analysis is performed.

TABLE DATA (major parameters)

F	= Soil nail axial tension force for critical failure surface (may not be the greatest)
Fmax	= Maximum soil nail tension from all analyzed critical failure surfaces
CAP STR	= Tensile structural design capacity for soil nail
CAP GEO	= Tensile geotechnical pull out resistance for soil nail
TcapGEO	= Critical shear resistance for soil nail (min TC1, TC2, TC3, TC4)
TC1	= Structural soil nail shear resistance
TC2	= Shear resistance according to Clouterre TC2 criterion
TC3	= Shear resistance according to Clouterre TC3 criterion
TC4	= Shear resistance according to Clouterre TC4 criterion
TC4 C4	= Shear resistance according to Clouterre TC4 criterion for limit equilibrium approach
kS	= Soil subgrade modulus reaction at failure surface-soil nail intersection point
Po	= Soil lateral pressure at failure surface-soil nail intersection point
Pu	= Ultimate lateral pressure at failure surface-soil nail intersection point
Lo	= Flexure length for shear calculations
IxxCalc	= Nail moment of inertia (adjusted for corrosion loss if assumed etc)
SxxCalc	= Nail section modulus (adjusted for corrosion loss if assumed)
t.loss	= Structural thickness loss (if assumed by the user)
%STR	= Structural capacity loss as a percentage (if assumed by the user)

Soil nail input data for design section STA 2+07 Seismic

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
Nail 1	1: N1 - #6	15	-1	220	12	0	5	0.44	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D or [illegible]	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	[illegible]	Studs	c studs	Bars
Nail 1	220	12	2	50	[illegible]1	N/A	N/A	#6

BEARING CAPACITY

Level Ground Conditions

Renton to Bellevue
Wall 6.50L Barrier

Calculate

Note: Any set of consistent units can be used

Ref: Das, "Principles of Foundation Engineering," Section 3.4

(B'<=L')

Phi, ϕ, (deg)=	36.0	Nc =	50.59	Width, B =	2.3	e=	0.0	B'=	2.33
Phi, ϕ,(rad)=	0.63	Nq =	37.75	Length, L =	25.(	e=	0.0	L'=	25.00
beta(deg)=	0.0	Nγ =	56.31	Area =	58	D/B=	0.43	Eff Area =	58.25

Load inclination from vertical

c	Nc	Fcs	Fcd	Fci			q (force/area)	Q (force)
0.0	50.59	1.07	1.17	1.(			0	0
γ	D (depth)	Nq	Fqs		Fqi			
125.0	1.0	37.75	1.07	1.11	1.00		5573	324601
	B (width)	γ	Nγ	Fγs	Fγd	Fγi		
1/2	2.3	125.0	.31	0.96	1.00	1.00	7895	459857

Verification blem, see attached photocopy
Exampl , page 114 in DAS (1984)
Prin s of Foundation Engineering

ultimate =	13,467	784,458
FS =	1.00	1.00
allowable =	13,467	784,458

Active & Passive Earth Pressure Coefficients -- Coulomb's Method

Wall 6.50L Barrier

Spreadsheet Name: RetWall, Notebook = Coulomb

References:

Das (1984), Principles of Foundation Engineering, eqs. 5-18, 5-24

Das (1983), Fundamentals of Soil Dynamics, eq. 9.5 & 9.41

Kramer (1996), Geotechnical Earthquake Engineering, eq. 11.21

Active & At-Rest Earth Pressures

		deg	rad
Friction angle	phi (φ)=	36.0	0.6283
Wall friction angle	delta (δ)=	23.8	0.4147
Backfill angle (0 horiz)	alpha (α)=	26.0	0.4538
Wall inclination (90 vert)	beta (β)=	90.0	1.5708

Unit Weight Gamma (γ) = 125.0

Wall Height, H = 0.0

Vertical Seismic Coeff. 0

Horizontal Seismic Coeff. 0.26

	deg	rad	sin
beta + phi =	126.0	2.199	0.809
beta - delta =	66.2	1.156	0.915
phi + delta =	59.8	1.043	0.864
phi - alpha =	10.0	0.175	0.174
beta - delta =	66.2	1.156	0.915
alpha + beta =	116.0	2.025	0.899

	deg	rad	cos	sin
theta =	14.6	0.254	0.968	0.2[illegible]
i = 90-beta	0.0	0.000	1.000	[illegible]
phi - theta - i =	21.4	0.374	0.931	[illegible]
delta + i + theta =	38.3	0.669	0.78[illegible]	[illegible]
phi - theta - alpha =	-4.6	-0.080	[illegible]	-0.080
alpha - i =	26.0	0.454	[illegible]99	

Ka =	0.35	
Ko =	0.59	
P (lbs)=	0.00	

EFP (pcf) =

Active	43.89
At Rest	74.11

Kae =	1.1[illegible]
Pae (lbs)=	[illegible]00
EFPae (pcf)=	[illegible]42.68

$$\theta = \tan^{-1}\{\frac{k_h}{1-k_v}\}$$

ΔKae (net)= 0.79

E'Quake 98.79

Passive Earth Pressure

		deg	rad
Friction angle	phi (φ)=	36.0	0.6283
Wall friction angle	delta (δ)=	11.9	0.2073
Backfill angle (0 horiz)	alpha (α)=	0.0	0.0000
Wall inclination (90 vert)	beta (β)=	90.0	1.5708

Unit Weight Gamma (γ) = 125.0

	deg	rad	sin
beta - phi =	54.0	0.942	0.809
beta + delta =	101.9	1.778	0.979
phi + delta =	47.9	0.836	0.742
phi + alpha =	36.0	0.628	0.588
beta + delta =	101.9	1.778	0.979
alpha + beta =	90.0	1.571	1.000

	deg	rad	cos	sin
theta=	14.6	0.254	0.968	0.252
i=9[illegible]a	0.0	0.000	1.000	
[illegible]theta=	50.6	0.883	0.635	0.772
[illegible]lta - i + theta =	26.5	0.462	0.895	0.445
phi+delta=	47.9	0.836	0.671	0.742
phi+alpha-theta=	21.4	0.374	0.931	0.365
delta-i+theta=	26.5	0.462	0.895	0.445
alpha-i	0.0	0.000	1.000	0.000

	FS=	1.00
Kp =	6.05	6.05
ΔKpe=	-3.75	

EFP (pcf) =

Passive [illegible]6.12

Kpe= 2.30

$$Ka = \frac{\sin^2(\beta+\phi)}{\sin^2\beta * \sin(\beta-\delta) * \left[1 + \sqrt{\frac{\sin(\phi+\delta) * \sin(\phi-\alpha)}{\sin(\beta-\delta) * \sin(\beta+\alpha)}}\right]^2}$$

$$Kae = \frac{\cos^2(\phi-\theta-i)}{\cos\theta * \cos^2 i * \cos(\delta+i+\theta) * \left[1+\sqrt{\frac{\sin(\phi+\delta) * \sin(\phi-\theta-\alpha)}{\cos(\delta+i+\theta) * \cos(\alpha-i)}}\right]^2}$$

$$Kp = \frac{\sin^2(\beta-\phi)}{\sin^2\beta * \sin(\beta+\delta) * \left[1 - \sqrt{\frac{\sin(\phi+\delta) * \sin(\phi+\alpha)}{\sin(\beta+\delta) * \sin(\beta+\alpha)}}\right]^2}$$

$$Kpe = \frac{\cos^2(\phi+i-\theta)}{\cos\theta * \cos^2 i * \cos(\delta-i+\theta) * \left[1 - \sqrt{\frac{\sin(\phi+\delta) * \sin(\phi+\alpha-\theta)}{\cos(\delta-i+\theta) * \cos(\alpha-i)}}\right]^2}$$